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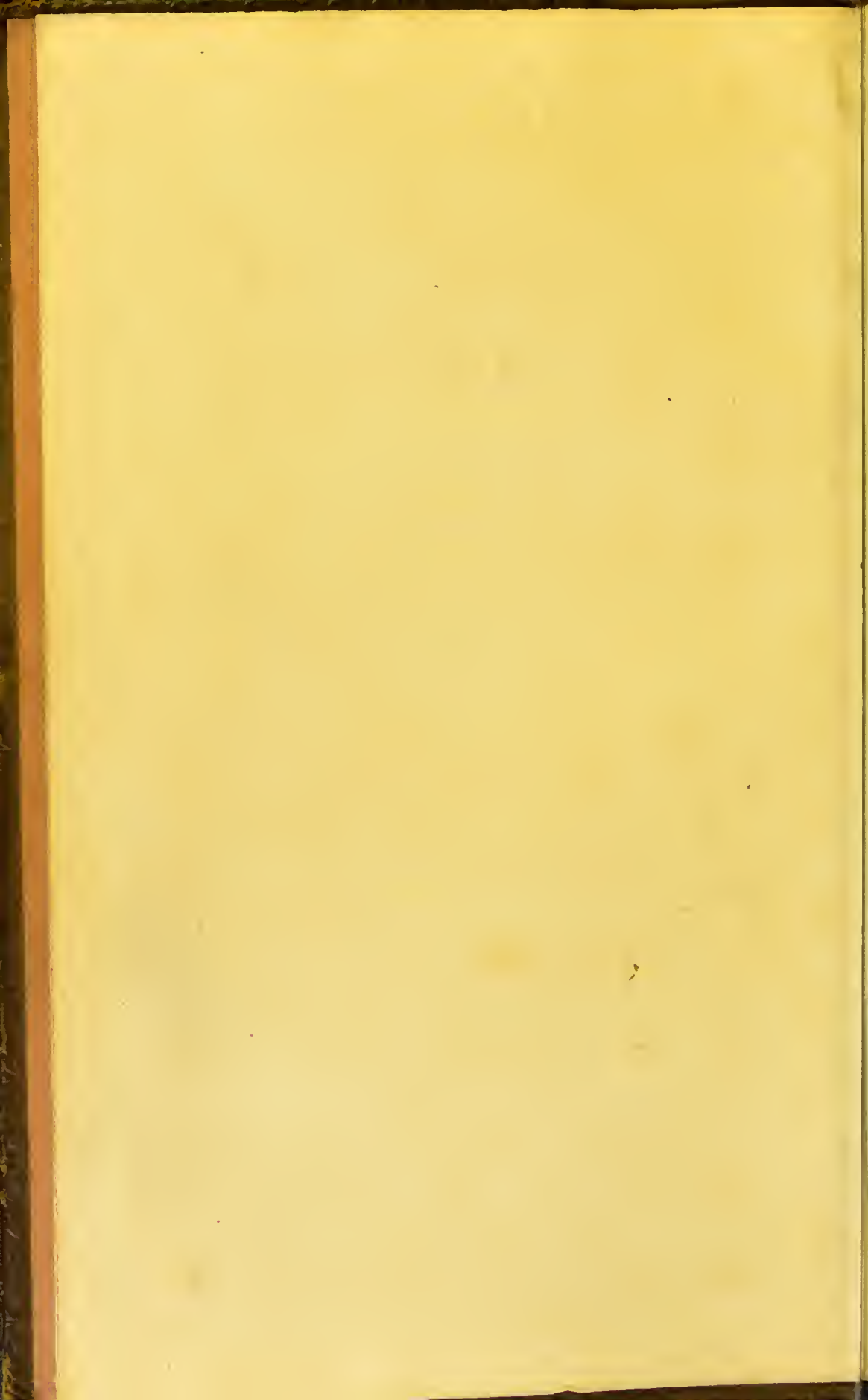
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Designed chiefly for the Use of Manufacturers.

THE
CHEMICAL PRINCIPLES
OF THE
METALLIC ARTS;
WITH AN ACCOUNT OF THE PRINCIPAL DISEASES
INCIDENT TO THE DIFFERENT ARTIFICERS;
THE MEANS OF
PREVENTION AND CURE;
AND A
CONCISE INTRODUCTION
TO THE
STUDY OF CHEMISTRY.

BY W. RICHARDSON, SURGEON, F. S. A. Sc.

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P R E F A C E.

IF knowledge be valuable in proportion as it is productive of beneficial effects to mankind; chemistry undoubtedly will bear the preference. The importance of health is sufficiently obvious; the principal processes which are carried on in the animal body to produce that state, are entirely dependent on chemical principles; and the derangements and interruptions which frequently occur and constitute disease, are principally remedied by the *chemical* action and combination of medicines. Yet, in a state of health, our happiness would be of short duration, were chemical principles confined to animal processes; for the means which the great Lord of the Creation has appointed to support it, are so immediately connected with them; that a temporary suspension of them in the grand œconomy of nature, would be fatal to all animal life.

Agriculture which supplies all our necessities, derives its power from chemistry. The mechanical operations of husbandry, only dispose the earth to perform those processes essential to vegetation with greater facility. The efficacy of manures, as afford-

ing warmth, moisture, or nutriment, for the tender plants, can only be deduced from chemical principles; and the very growth and perfection of them, can only be promoted by the assimilation of simple particles, produced by various chemical decompositions and new combinations. So that "Chemistry
" is of the same importance to agriculture, and all
" the more particular branches of rural œconomy
" that astronomy is to navigation."

With respect to the arts, most of them depend on chemistry for their perfection. The smelting of ores; the manufacturing of metals; the elegance and durability of dying; the making of glass, porcelain, &c. all derive their great beauty and utility from the same source. Most of these processes are conducted by artists who are intirely ignorant of their principles; but in general have acquired a considerable degree of certainty and ingenuity from practice. But should any unexpected circumstance arise, which they have not experienced before; they are involved in a difficulty which all their practice cannot extricate them from; and which in all probability can only be surmounted, by a proper reference to, and application of, the principles of the art. So that many losses must unavoidably be incurred in working, from the want of such fundamental knowledge.

P R E F A C E.

To obviate which in some degree, in the metallic arts, was the principal inducement for the present undertaking. The introduction to the study of chemistry is by no means offered as perfect; it is only intended to communicate general ideas on the subject; but the author flatters himself, that should it incite a desire of being farther informed, that it will much facilitate the understanding of more scientific writers.

The knowledge of metallic artists, seldom extends farther than what immediately concerns their own employment; many of them have not the least conception of the method of extracting metals from their ores; or of the application of them to such various purposes; the author therefore presumed, that a publication of this nature exhibiting their origin, chemical properties, and different combinations; might be really serviceable to the different manufacturers, whose interest it is to gain such general information. Authors of the greatest eminence have been consulted and used on the present occasion; and whenever they have been deficient in point of practice, application has been made to working artists: so that every endeavour has been exerted to render the work as useful as possible. And with a view to make it still more serviceable, a short account of the most troublesome disorders, to which such persons are exposed,
is

is inserted in the end; accompanied with some plain and general directions respecting the means of prevention and cure. By attending to these, it is hoped the artists will be enabled to obviate and remove many of their sufferings. It is proper however to inform them, that these directions are not meant to set aside in every case application to the faculty, to whom on the contrary we would advise them to have recourse, if their complaints do not yield to the methods therein proposed.

The Author takes this opportunity of acknowledging that in this part of the work, he is indebted to a Friend and Physician of the town in which he resides for several hints.

To enable those who have a taste for experiment, to make them on a small scale, we have given a general description of instruments for the purpose of philosophical chemistry. We could not give a description of those employed in the working at large without plates of reference, which would have been expensive; but should the public ever demand a second edition, they are intended to be added.

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ERRATA.

- Page lxvi, Line 11. *for* Spirit Sal of Ammoniac,
read Spirit of Sal Ammoniac.
Page lxxxiv, Line 2. *for* vitriable, *read* vitrifiable.
Page 85. *for* Plantina, *read* Platina.
Page 103, Line 12. *for* Amalgaman, *read* Amalgam.
— ib. — 14. *dele* in.
— 104, — 7. *for* of, *read* off.
— 191, — 13. *for* pepperment, *read* peppermint.

A
CONCISE INTRODUCTION
TO THE
STUDY OF CHEMISTRY.



INTRODUCTION.

CHEMISTRY is divided into two parts, viz. analysis, and synthesis.

I. Analysis is the decomposition or resolution of bodies, into their constituent parts.

II. Synthesis is the re-composition of such parts, forming the original compound.

THE subjects of chemistry, are all bodies produced either by nature or art. It is only by certain means, that we can investigate the principles of such bodies; these means are called chemical processes; and consist of

I. RESOLUTION.

BY resolution is meant the division of the various substances, composing a simple or mixed body; reducing it either into its integrant or component parts.

The integrant parts of a body, are the smallest particles into which it can be divided, without separating its component parts.

The component parts of a body, are the different substances united together, forming the compound; as the mineral alkali and muriatic acid, are the component parts of common salt.

II. MIXTURE.

MIXTURE, is the combination of different bodies among themselves, and may be found in three states, viz. First, mechanical mixture; secondly, diffusion; and thirdly, chemical union.

I. Mechanical mixture, is when the particles of the one body attract one another more strongly, than those of the other body; in this case, the substance in smallest quantity, is broken into small masses, which are surrounded by the particles of the other; and the two substances are separable, by subsiding. A mixture of chalk and water, exemplifies this mode of combination.

II. Diffusion, is when the particles of one substance, attract those of another, as strongly as they do one another; so that the substances are broken down
into

into their smallest integrant parts; and are uniformly mixed, but may be separated by filtration or freezing. It is on this principle of combination, that dyers work.

III. Chemical union, is when the particles of one substance attract the particles of another, stronger than they attract one another; and the union can only be destroyed, by the addition of some other simple or compound body; which has a stronger attraction, to one or both of the constituent parts of the first combination.

III. SOLUTION.

WHEN a solid body is dissolved in a fluid, without destroying its transparency; as common salt dissolved in water; the operation is called solution. As the water is looked upon to be the principal agent, it is called the solvent, or menstruum; and the salt the solvend.

IV. SATURATION.

AS a solvent cannot act unlimitedly, but can only dissolve a certain portion of the solvend; when it arrives at that point, which makes it incapable of dissolving any more; the solvent is said to be saturated.

Saturation may be divided into six different species, which include all that can possibly take place.

I. Solids with liquids. Of this we have a striking instance in gypsum and water. Water poured on gypsum to a certain quantity, becomes consolidated; but if more than that quantity be added, it becomes liquid.

II. Liquids with solids, as in the saturation of water with common salt.

III. Solids with vapor. The common fixed alkali, will unite with a certain quantity of fixed air; in a manner so strong, as to be only separable by elective attraction.

IV. Liquids with vapor. Common water will absorb muriatic acid, and condense it to a certain degree; beyond which, however long the water be exposed to such vapor, no farther absorption can possibly take place.

V. Liquids with each other. Rectified spirit of wine is the best solvent of essential oils; but the solution is confined to a certain degree; beyond which the oil becomes super-abundant, and can only be suspended. And

VI. Va-

VI. Vapors with each other. Let volatile alkali be converted into vapor, by the application of heat. Near this vapor detach the marine acid, by adding a little vitriolic acid to common salt; the vapor of the marine acid will unite with the vapor of volatile alkali, to the point of saturation, and form white flakes of sal ammoniac.

Solution and saturation are promoted three ways. First, By agitation. Secondly, By minute division; and Thirdly, By heat.

I. If a piece of sugar be put into a little water, and suffered to remain at rest; it will require some time before it be dissolved; for the water immediately in contact with the sugar, will become saturated; and from its difference of specific gravity remain at the bottom; but agitate it a little with a spoon, and the solution soon takes place.

II. The manner in which minute division promotes solution, is as follows: Bodies are acted upon in proportion to the degree of surface, which the solvent exposes to the solvent; so that, if the solvent be reduced to a powder, by encreasing its surface, the solvent has more parts to act upon, and consequently dissolves it with greater ease and facility. And

III. Heat by encreasing the bulk of the solvent, and promoting an agitation of its parts, causes a greater surface, and a quicker application of its particles to the solvend, by which the process is much facilitated.

Deliquescence is a mere solution, and has obtained a different appellation, on account of its being differently performed. It takes place in salts of easy solution, and is effected by absorbing the water contained in the atmosphere.

V. CRYSTALLIZATION.

IN the solution of any salt in water, every particle of water attracts to itself, and keeps suspended a particle of salt of a definite weight; therefore crystallization, is an operation by which, the integrant parts of a body, separated by the interposition of a fluid; are disposed to unite again into solid, regular, and uniform masses. To give as true an idea of crystallization as possible, we must observe; first, that the particles of all bodies are disposed to unite together, unless they be prevented by the interposition of some extraneous substance. Secondly, This disposition is more perceptible in simple or little compounded bodies; than in others more compounded. Thirdly, The integrant parts of certain bodies, have the

the same constant, uniform, and peculiar figure; and fourthly, if the integrant parts of such bodies be equal and similar; all the parts will have an equal tendency to unite; but, if they be made dissimilar, they may unite indiscriminately; it is probable that the disposition of such parts to form an union, is influenced by the extent of surface of the different sides.

Now, if the integrant parts of a body, be kept apart by the interposition of a fluid, and this fluid be evaporated by heat; in proportion as the fluid is evaporated, the separated particles will approach to each other, till at last they unite. They may also unite together before the whole of the interposed fluid be evaporated; if the attraction subsisting between the integrant parts of the solvent, be sufficient to overcome the resistance of the solvent; and then by giving them time to unite together by the sides most disposed to such union, they will crystallize into figures constantly uniform and similar.

The regularity of crystals, depends upon certain circumstances. If the solvent be evaporated too hastily, the component parts will approximate and unite, before they have taken the position of their natural tendency; and will join indiscriminately, and thus form figures irregular and various.

If the evaporated solution be cooled too fast; then the crystals will be of different figures.

To procure the best and most perfect crystals, the evaporation should be gentle, and the cooling very gradual.

It frequently happens, that several salts are dissolved in the same menstruum; the separation of which is attended with more or less difficulty.

In the crystallization of different salts, it must be observed, that they shoot into crystals at different times of the evaporation. Because, some salts require more and others less water for their solution; and again, some crystallize best by cooling; and others by continuing the evaporation. Nitre crystallizes best by cooling, and common salt by continuing the evaporation; so that if there be a solution of those salts in the same menstruum; and a separation of them be desired; after the solution has been evaporated, it should be set by to cool, when the crystals of nitre will shoot; and this should be repeated till the whole nitre is collected; then, as you continue to evaporate the water, the common salt will be continually crystallizing.

Some

Some of the salts have the power of acting upon each other, so as to cause each to be dissolved in a larger quantity, in the same portion of menstruum. When they act as inter-media, upon each other, as sal ammoniac, and corrosive sublimate, they cannot be crystallized separate by any method.

Salts composed of marine or nitrous acid, with calcarious earth, copper, or iron, cannot be separated by crystallization; because they all require to be evaporated nearly to dryness; consequently their crystals will become intermixed.

In the crystals of the various salts, there is a portion of water, which has no relation to the salts themselves; and is called the WATER of CRYSTALLIZATION.

Previous to our entering on separation or decomposition, it will be necessary to explain a few terms of art, more immediately connected with that process. First, PRECIPITATION. We would confine this term to the falling down of bodies in a solid form. It has been used in a very loose indeterminate sense: authors have talked of the precipitation of vapors, which is erroneous, from their specific levity they will be suspended, if they become condensed, they will be precipitated in a visible form; as the condensed vapor of water, forms rain. But the precipitation

pitiation which attends chemical decomposition, I would say, is the separating and falling down of one substance from another, in the form of a solid; when the combined substances were in a liquid or fluid state. As for instance, dissolve silver in pure aqua fortis, the solution is clear and transparent; but by adding a clean plate of copper to the solution, a white powder is immediately formed, which falls to the bottom, and is called the **PRECIPITATE**. During the solution of the silver in the nitrous acid, a certain motion is produced, which has been called **EBULLITION**. This term has been indiscriminately applied to this phenomenon, and to the boiling of water; but as the same appearances are produced from separate and distinct causes, they should be defined by separate and distinct terms; therefore, **EBULLITION** should be confined to the boiling of water only; and **EFFERVESCENCE** should be applied to that intestine motion produced from chemical solution.

VI. *On* SEPARATION *or* DECOMPOSITION.

THIS subject is the most important in the study of chemistry; as on this principle depends the whole of analysis.

By decomposition, we mean the resolution of bodies into their component parts. This effect is produced,

produced, by that superiority, which one body possesses over another, of forcing it from its situation; and taking its place. This property is called by the French affinity, we call it elective attraction; speaking of it as a being, which has the power of making an election with respect to its union with another body. In consequence of this elective attraction, compleat changes take place in substances, and new compounds are produced.

The effect of elective attraction, may be seen by repeating the following experiments.

I. Take a solution of Epsom salt, which is composed of vitriolic acid and magnesia; to which add, a few drops of a solution of any alkaline salt, and the magnesia will fall to the bottom. The vitriolic acid, having a stronger attraction to the alkali, than to the magnesia; quits the first combination, to unite with the alkali, while the magnesia, is precipitated.

II. Put in a glass, a small quantity of a solution of marble in muriatic acid; to this solution add some vitriolic acid, it will unite with the marble, and form a solid gypsum; while the muriatic acid will fly off in vapor.

In the first experiment, the united bodies remain liquid, while the decomposed body falls to the bottom in a solid form; but in the second experiment, the united bodies form a solid, while the separated body evaporates away in form of vapor.

In producing these changes, there are two forces to be overcome, viz. the attraction of COHESION, and the VIS-INERTIA. Now, if any third body has the power of overcoming these forces, decomposition unavoidably takes place. The ATTRACTION of COHESION may be overcome by ELECTIVE ATTRACTION, and the vis inertia, by first, difference of specific gravity. If the body united, makes the compound of less specific gravity, than the body decomposed; then the decomposed body must be precipitated to the bottom: and secondly, REPULSION. This is clearly the case, when vapors are separated; for as they are condensed into very narrow limits during their union; no sooner are they set at liberty, than their power of expansion begins to act, and their particles mutually repel each other, to a distance from the substance they have been extricated from; as in the instance of the decomposition of nitre, by the addition of a little vitriolic acid, when the spirit of nitre flies off in an orange colored vapor.

This

This is an example of single elective attraction, or, where by the addition of a third body, a compound is deprived of one of its constituent parts; a separation which will resist all the combined powers of mechanics, is here produced simply by the addition of a third substance. But this power is still farther extended in the double elective attraction; or, when a compound body is decomposed, by adding another compound substance. If to a solution of the vitriolated tartar, which is composed of vitriolic acid and vegetable alkali; you add a few drops of a solution of lunar caustic, which is formed of silver and the nitrous acid, a decomposition immediately takes place. The nitrous acid of the lunar caustic, has a strong attraction for the alkaline base of the vitriolated tartar, but not sufficient of itself to dislodge the vitriolic acid; this want of power in the nitrous acid, is made up by the attraction, which subsists between the vitriolic acid and the calx of silver. To make this case clear, we will illustrate it by figures, not that I mean to say, that such figures will shew exactly the relative forces, of the attraction of the different substances; but it will give a clearer idea of the subject, than by any other mode which I know of. Suppose the vitriolic acid to attract the vegetable alkali, with a power equal to 9. The nitrous acid has an attraction to the same alkali, but with a force equal only to 8; consequently cannot decompose

decompose it, being below the other power of attraction. The nitrous acid has a power of attraction equal to 2 to overcome, before it can dislodge the vitriolic acid; now, the relative attraction between the vitriolic acid and the calx of silver, is equal to 4; which being added to the attraction of the nitrous acid, for the alkali will produce a power equal to 12, and the change accordingly takes place.

Separation or decomposition may be produced by two modes. First, *Viâ humidâ*, or by the HUMID WAY; which is by solution in one or various menstrua; and secondly, *viâ ficcâ*, or the DRY WAY; which is the solution of one solid body in another, by fusion or trituration; as in extracting the silver from silver ore, by fusing it with lead; or the extracting of gold from its ore, by triturating it with quicksilver.

Since the principle of elective attraction has been discovered, chemists have employed themselves diligently, to find out the different substances which attract each other; and to compare their relative forces. This they did, till such a number of instances occurred, that the memory could no longer contain them; in consequence of which, they digested them into tables, which are called tables of elective attraction.

A TABLE of the AFFINITIES of the different METALS, in the DRY WAY.

Gold	Platina	Silver	Copper	Iron	Tin	Lead	Zinc	Arsenic	Bismuth	Reg. Anti.	Manganese	Cobalt	Nickel	Qu. Silver
Mercury	Arsenic	Lead	Gold	Nickel	Mercury	Gold	Copper	Nickel	Lead	Iron	Copper	Iron	Iron	Gold
Copper	Gold	Copper	Silver	Cobalt	Copper	Silver	Antimony	Cobalt	Silver	Copper	Iron	Nickel	Cobalt	Silver
Silver	Copper	Mercury	Arsenic	Arsenic	Antimony	Copper	Tin	Copper	Gold	Tin	Gold	Arsenic	Arsenic	Platina
Lead	Tin	Bismuth	Iron	Manganese	Gold	Mercury	Mercury	Iron	Mercury	Lead	Silver	Copper	Copper	Lead
Bismuth	Bismuth	Tin	Manganese	Copper	Silver	Bismuth	Silver	Silver	Antimony	Nickel	Tin	Gold	Gold	Tin
Tin	Zinc	Gold	Zinc	Gold	Lead	Tin	Gold	Tin	Tin	Silver		Platina	Tin	Zinc
Antimony	Antimony	Antimony	Antimony	Silver	Iron	Antimony	Cobalt	Lead	Copper	Bismuth			Antimony	Bismuth
Iron	Nickel	Iron	Platina	Tin	Manganese	Platina	Arsenic	Gold	Platina	Zinc			Platina	Copper
Platina	Cobalt	Manganese	Tin	Antimony	Nickel	Arsenic	Platina	Platina	Nickel	Gold			Bismuth	Antimony
Zinc	Manganese	Zinc	Lead	Platina	Arsenic	Zinc	Bismuth	Zinc	Iron	Platina			Lead	Arsenic
Nickel	Iron	Arsenic	Nickel	Bismuth	Platina	Nickel	Lead	Antimony	Zinc	Mercury			Silver	Iron
Arsenic	Lead	Nickel	Bismuth	Lead	Bismuth	Iron	Nickel			Arsenic			Zinc	
Cobalt	Silver	Platina	Cobalt	Mercury	Cobalt		Iron			Cobalt				
Manganese	Mercury		Mercury											

*

* The METAL at the Head of each Column, has a stronger Attraction for that immediately below it, than for any of the Others, to the Bottom; so that Metals in Fusion may sometimes be separated from each other by the Advantage of these Affinities.

VII. *On* DISTILLATION.

THIS is a process in which heat is applied to decompose bodies. A great variety of vessels has been used for this purpose. As the substances distilled, are first converted into vapor, and afterwards condensed; the mode of distillation is named according to the escape of the vapor. If the fire be placed beneath the body of the still, so that the vapor rises before it is condensed, it is called distillation per ascensum, or by ascent. If the vapor be made to pass downward and is condensed in a proper vessel, it is called distillation per descensum, or by descent; and if the distillation be performed with a retort, at the neck of which is joined a recipient or receiver; it is called per latus, or by the side; or per retortam, by the retort.

The substances to be distilled, are put into the body of the still, as the leaves of plants, and a sufficient quantity of water put thereon; a gentle heat is applied, which converts the water into vapor. This vapor is impregnated with the volatile parts of the leaves; is condensed, and forms the distilled water of the particular plant used. This is called SIMPLE DISTILLATION.

A TABLE shewing some of the most useful single elective ATTRACTIONS in the HUMID WAY.

[illegible]

But this kind of distillation will not answer all the purposes, which chemists want; for in the distillation of nitrous acid, the nitre cannot be decomposed by simple distillation. There arises a necessity of making an addition, before the effect can be produced; which is done by adding the vitriolic acid, which unites with the alkaline base of the nitre, and sets at liberty the nitrous acid. This mode is called DISTILLATION with ADDITION.

The purposes of distillation are three. First, To obtain the volatile parts of bodies in a condensed state, as the essential oils; secondly, If the component parts of bodies be fixed, to obtain that part we want by addition; and thirdly, by attending to the different degrees of heat, we may separate a body we want from another, which is volatilised at nearly the same degree of heat.

VIII. SUBLIMATION:

THIS is upon the same principle as the distillation per ascensum; with this difference only; that the product in the distillation is always in a liquid form; and in sublimation, in a solid form. When the substances sublimed appear like a fine soft powder, chemists call them flowers; as the flowers of sulphur, flowers of benjamin, &c. This operation may be performed with phials luted to each other, in alludels, &c.

IX. On

IX. *On* EVAPORATION.

THIS operation is used for separating two substances from each other, one of which at least, must be fluid, and whose degrees of volatility are very different. By this means we obtain a salt, which has been dissolved in water, in its concrete form; the water by uniting with the matter of heat, becomes volatile, and the particles of salt being brought nearer to each other, come within the sphere of their mutual attraction, and unite into a solid state. As it was long thought that the air had great influence upon the quantity of fluid evaporated; it will be proper to point out the errors, which this opinion has produced. There certainly is a slow evaporation from fluids exposed to the air; this may be considered in some degree as a solution in air, yet the matter of fire has considerable influence in producing it, as is evident from the cold which always accompanies this process; hence, we may consider this gradual evaporation as a compound solution, made partly in air and partly in the matter of fire. The evaporation from a fluid continually boiling, is quite different in its nature, and in it, the evaporation produced by the action of the air, is exceedingly inconsiderable, in comparison with that which is made by the heat. This process is not accelerated in pro-

portion to the extent of evaporating surface, but in proportion to the quantity of heat, which combines with the fluid. A current of cold air retards this process, by carrying off the heat from the water; hence no inconvenience arises from covering the vessel, provided sufficient vent be given for the vapor to escape; and the covering body be a bad conductor of heat. By this mode, there is frequently more evaporated, than when free access is allowed to the external air.

X. FUSION.

THIS operation is commonly performed in vessels called crucibles. Metals exposed to heat become liquified, which state is called fusion. It may often take place, without changing the nature of the fused body. It is frequently employed as a chemical means of decomposing and recompounding bodies. In this way, all metals are extracted from their ores; and by this process, they are revived, moulded, and alloyed with each other; by this process sand and alkali are combined to form glass; and by it, likewise paste, or colored stones, enamels, &c. are formed. The latter process, is called VITRIFICATION.

XI. *On* FILTRATION.

A filtre is a species of a very fine sieve, which is permeable to the particles of fluids, but through which the particles of the finest powdered solids are incapable of passing; hence its use in separating fine powders from suspension in fluids. For the purposes of chemistry, as it is requisite to have the filters perfectly clean, unsized paper is substituted instead of cloth or flannel; through this substance, no solid body, however finely it be powdered, can penetrate, while fluids percolate through it with the greatest readiness.

XII. *On* DECANTATION.

THIS operation is often substituted instead of filtration, for separating solid particles, diffused through liquors. These are allowed to settle in proper vessels, and the clear liquor is gently poured off. If the sediment be extremely light, and apt to mix again with the fluid by the slightest motion, the syphon is used instead of decantation for drawing off the clear fluid.

XIII. *On* CALCINATION.

IN every calcination, some volatile parts are expelled by the fire, even supposing them to be nothing else than phlogiston, air, and water. Hence this operation cannot be performed in a vessel perfectly closed, and from which there is no possible egress.

Calcination in the proper and strict sense of the word, is the mere operation of fire upon metallic bodies, calcareous earths, and in the incineration of animal and vegetable substances. Calcination may, therefore, be distinguished by the name perfect, from another which is imperfect, and performed by acrid saline substances of various kinds. The products of a perfect calcination, are called *CALCES*, especially when they are of a white color; but when of a yellow, brown, or red, they are called *SAFFRONS*. When a metallic substance has been calcined by acrid salts, the operation is called *CORROSION*, but the product is called *RUST*. *REVERBERATION*, is a mode of calcination, by which the bodies subjected to it, are struck by the fire from every side. *ROASTING* of *ORES*, is a species of calcination. *CEMENTATION*, by acrid salts and heat, and *DETONATION*, by projecting nitre on metallic bodies in fusion, are both modes for promoting the same end.

Scorifi-

Scorification and cupellation, are terms used for the same process.

XIV. *On* REDUCTION.

THIS is an operation which takes place on metals only ; by which, whenever they have lost their metallic appearance, they are restored to their proper metalline state again. As metals may be deprived of their splendor by two different ways, either by the privation of their phlogiston by calcination ; or by uniting them with extraneous substances, as in corrosion, &c. the reduction must consequently depend on a two-fold cause, and requires either, that the metallic earths should have that which they have lost restored to them ; or that the extraneous substances which have been united with these calces, should be separated from them. The parts which the metallic calces have lost, are restored by fusing them with substances containing phlogiston. The extraneous substances are destroyed by alkalies, borax, lime, &c. but if it should be sulphur, alkalies then are very improper, as they would unite with it and form a hepar, and dissolve a portion of the metal. There is at all times a great difference observable in reductions. Some are performed with ease, some on the contrary with great difficulty ; and require besides to be managed in various ways. Some

may be reduced in open crucibles; whilst others are only to be reduced in close vessels. In some cases, the whole of the metal, which is contained in the body to be reduced is obtained; in others, on the contrary, a considerable quantity of it is lost.

This process is much promoted by the assistance of the different fluxes, and succeeds best, when there still subsist in the body which is to be reduced, some inflammable particles; without which the phlogiston of the reducing substances, cannot so easily combine with the calcined earthy particles, and consequently reduce the metal.

XV. EXTRACTION.

IN admixtures, sometimes there are parts which are soluble in particular menstrua, the separation of which is called extraction. This may be effected either by maceration, or steeping the subject in its appropriate solvent in the cold; or by digestion, which may be either with or without heat, but in general, digestion implies the use of heat.

XVI. EXSICCATION.

BY exsiccation is meant the drying of moist bodies, which is performed either, first, by heat, which
evaporates

evaporates the humid parts; or secondly, by applying substances of a soft and spongy texture, which imbibe the super-abundant moisture.

XVII. LIXIVIATION.

THIS is an operation used in chemistry and the arts, for separating substances which are soluble in water, from such as are insoluble. The substance to be lixivated is put into a convenient vessel, and then either hot or cold water is poured upon it, according to the degree of solubility of the saline matter. This is repeated, till the water which comes off is entirely free from salt, which is judged of by the taste, or more accurately by the hydrometer.

XVIII. A GENERAL DESCRIPTION *of* INSTRUMENTS, *for the* PURPOSE *of* PHILISOPHICAL CHEMISTRY.

THERE are few who have it in their power to fit up a complete laboratory on a large scale; but as many important discoveries have been made upon very simple apparatus, we will enumerate those simple instruments most necessary for a philosophic chemist.

I. RETORTS of various sizes, composed of glass, earthen ware, or the different metals. †

II. RE-

II. RECEIVERS of various sizes, composed of glass, or earthen ware.

III. PHIALS of different sizes, some perforated on one side, and others on both, with various sized glass tubes; some straight, and others bent or curved.

IV. GLASS JARS of various sizes, some graduated, and others plain.

V. MATRASSES of different sizes, some composed of glass, and others of earthen ware.

VI. CRUCIBLES of various sizes, common, black lead and metallic. To which may be added, CAPSULES, which are small faucers, composed of pure clay, or clay and sand; and TESTS which are composed of calcined bone dust. MUFFLES and CEMENTING POTS, as being composed of the same materials, may properly be mentioned in this place.

VII. GLASS FUNNELS of various sizes, with a separating funnel.

VIII. A WOODEN TROUGH, to contain water, or quicksilver, with jars of different sizes, for a pneumatic apparatus.

IX. A PORTABLE FURNACE. The following description of a general furnace for experiment, may not be unacceptable. The body of the furnace should be made of sheet iron, groved together of a conical shape; the smallest diameter about six inches and a half, turned up to support a grate of bar iron. The largest diameter about a foot, over which should be a cover perforated with two holes, as far from each other as possible; the widest about five inches, the smallest three inches and a quarter; which is surrounded with a ring to support a funnel, which may communicate with the chimney of a common room. In the front of the furnace about two inches and a quarter, from the bottom should be an opening three inches and a quarter square, occasionally to be covered with a slide or door. It may be supported on a trivet, but room must be left for a sufficient current of air. Sometimes these furnaces are lined with clay, &c. when they must be made something larger, except in height. When all the apertures through which the air ought not to pass, be closed, a sufficient degree of heat is raised to smelt copper, copper-ores, cast iron, and even to reduce some of the less refractory iron ores. This furnace will serve for all the chemical processes, such as distillation, sublimation, &c. &c.

X. A BLOW PIPE. This is a very necessary instrument to reduce small portions of metallic ores to promote vitrifications, &c. with the flame of a candle or lamp. The flame of the candle or lamp, consists of two well defined colours, viz. blue and light orange; the heat of the blue color is most intense, consequently, this flame concentrated by the blow pipe, and a small quantity of ore supported on charcoal, or in a silver spoon, brought to its apex, with a small portion of flux, is soon brought into a state of fusion. By this method, small globules of glass may be tinged, and the nature of metallic ores thereby ascertained.

XI. COMMON SCALES and WEIGHTS, and a pair of hydrostatic scales to ascertain the specific gravity of bodies. The specific gravity of a metal or fossil, is thus found. Suspend the piece to be examined in a horse-hair loop, fixed to a hook at the bottom of a scale; poise it exactly by weights on the opposite scale; immerse it in a quantity of distilled water, and restore the equilibrium by putting weights into the lighter scale; these, indicate the weight of the quantity of water, which is equal in bulk to the metal, &c. under examination. Divide the sum of the weight in air, by the sum of the weight required to restore the equilibrium in water, and the quotient

quotient gives the specific gravity. If, for example the metal weighed in air 72 grains, and that when weighed in water, 9 grains were wanting to restore the balance, 72 divided by 9 gives 8; therefore the specific gravity of that metal is called 8; that is, it is 8 times heavier than water. To determine the specific gravity of a fluid, suspend a solid ball of glass by a horse-hair, to the arm of a balance. Poise it accurately by weights in the scale at the opposite end of the beam. Now sink the ball in distilled water, and take weights out of the scale till the beam stands horizontally; note the weights you have taken away; wipe the ball perfectly dry, immerge it in the fluid you wish to examine. The difference of the weights necessary to restore the equilibrium in the two fluids, denotes the specific gravity.

Authors generally signify specific gravity in decimal numbers, it is therefore necessary to understand them. This knowledge is easily acquired. First, It must be observed, that the figures before the comma are whole numbers, as in common arithmetic; those after the comma, are numerators, whose denominator is 10, 100, or 1000. These denominators are omitted, and the numerator only set down, five tenths are thus written, ,5; forty-five hundred parts, thus, ,45; and hundred and twenty thousand parts, thus, ,120. In these decimal fractions, cyphers

phers after the figure signify nothing, 500, means only five tenths; but before the figure they decrease its value, thus, .05 means five hundredth parts.

XII. Pair of hand bellows, tongs, and mortars, composed of metal and glass; iron ladles, shovels, and a cone.

XIII. LUTES. These are used for securing the juncture of vessels, in distillations and sublimations. For the distillation of water, linen dipped in a thin paste of flour and water is sufficient. A lute of greater security is composed of quick lime, made into a paste with the whites of eggs. For the security of very corrosive vapors, clay finely powdered and sifted, made into a paste with boiled linseed oil; must be applied to the juncture; which must be afterwards covered with slips of linen, dipped in the paste of quick lime and the whites of eggs. The lute must be perfectly dried before the vessels are used, or else the heat may cause it to dry too quick, and thereby cause the lute to crack. If this be the case, it is repaired by applying fresh lute in the cracks, and suffering it to dry gradually. Vessels which are to be exposed to the naked fire, are frequently coated to resist the effects of the heat; the best coating for which purpose, is that described by Willis, in the Transactions of the Society of Arts, vol,

vol. v. p. 96, which consists in dissolving two ounces of borax in a pint of boiling water, and adding to the solution as much slaked lime as is necessary to form a thin paste. The vessel must be covered all over with it by means of a painter's brush, and then suffered to dry. It must then be covered with a thin paste of linseed oil and slaked lime, except the neck. In two or three days it will dry of itself, and a retort will then bear the greatest fire without cracking. The cracks of chemical vessels may be secured by the second lute.

XIV. Burning glasses, magnifying glasses, a metallic lens, a thermometer, a small electrical machine, and two syringes, the one to extract, and the other to condense gases.

With these instruments, there are few experiments but what may be made with the greatest precision. We shall now proceed to the *materia chemica*.

There have been various methods of arranging natural bodies, so as to give their chemical history; but Dr. Black's, of Edinburgh, appears to me the most unexceptionable. He divides them into six CLASSES, viz. First, SALTS. Secondly, IN-

FLAMMABLE

FLAMMABLE BODIES. Thirdly, METALS. Fourthly, EARTHS. Fifthly, AIR; and Sixthly, WATER.

I. *Of* SALT S.

SALT S are a general term, comprehending three distinct species, viz. First, ACIDS. Secondly, ALKALIES; and Thirdly, NEUTRALS.

A C I D S.

THE term acid explains itself, by its common sensible property, of tasting sour. But this is not sufficient to discriminate acids under all circumstances; accordingly there are other general properties, which invariable characterize them. First, They unite with alkalies, earths, and metals, forming various neutral salts. Secondly, Particular acids united to particular alkalies, produce discriminating crystals; and thirdly, they change the tinctures, or infusions of the blue flowers of vegetables to red. There is but one exception to the last criterion, and that is in indigo, which is dissolved in vitriolic acid, without any change of color. The nicest chemical test of an acid is tincture of turnsole, which is prepared from a solution of litmus in distilled water, and assumes a blue color. A single grain of concentrated vitriolic acid communicates a visible red tinge to 172,300 grains, or 408 cubic inches of the blue tincture.

tincture. Syrup of violets is used for common experiments.

Chemists have divided acids into three classes, viz, MINERAL, VEGETABLE, and ANIMAL; according to the nature of the subject from which they are produced. The vegetable acids are subdivided into native and factitious, which are produced by fermentation. To the latter class may be referred those acids separable from vegetables by distillation. These generally have a burnt smell, and are called EMPYREUMATIC ACIDS.

I. MINERAL ACIDS.

I. VITRIOLIC ACID, commonly called OIL of VITRIOL, or SPIRIT of VITRIOL. The vitriolic acid is so called from the ancient method of extracting it from green vitriol. But now it is more profitably obtained from the combustion of sulphur. This acid when perfectly pure, is transparent; but its attraction for phlogistic substances is so strong, that whenever it comes in contact with them, it soon becomes of a dark color. Its specific gravity is double that of water; for if a pint of water weigh one pound, the same quantity of vitriolic acid will weigh two pounds. It has a very strong attraction for water.

It

INTRODUCTION.

It formerly was obtained from green vitriol, and pyrites, by distillation. Sulphur was found to produce it in great abundance from combustion; consequently, that substance was burnt under a large glass bell; the condensed vapor was an impure vitriolic acid, which was purified either by simple distillation, or by the addition of a small quantity of nitrous acid; which attracts the phlogiston; and is afterwards easily evaporated away by a gentle heat. This was called *OLEUM VITRIOLI PER CAMPANAM*; or oil of vitriol by the bell. It is now obtained by the combustion of sulphur, in rooms properly constructed and lined, which are called *SULPHUR CHAMBERS*. It unites with alkalies, earths, and metals, forming various neutral salts. When united with phlogiston it is volatilized, and has a very penetrating smell; in which state, it is called *VOLATILE SULPHUREOUS ACID*.

II. *MARINE ACID*, commonly called muriatic acid, or spirits of salt. Its color is a pale yellow with a greenish tinge. It is volatile in the heat of the atmosphere. Its specific gravity is to water as nineteen to sixteen. Its original form is a vapor, but it has a strong attraction for water, and therefore is generally in a liquid state. Its attraction for phlogiston is not so strong as the vitriolic acid. It is deprived of its phlogiston by distilling over manganese,

nese, and is then called **DEPHLOGISTICATED MARINE ACID**.

It is obtained by decomposing common salt with the vitriolic acid by distillation. The common salt is composed of marine acid and mineral alkali, the vitriolic acid has a stronger attraction for the alkali, therefore unites with it, and drives off the marine acid in form of a white vapor; which is condensed by water in proper vessels. It unites with alkalies, earths, and metallic calces, and forms various neutral salts.

III. ACID of BORAX. This acid has been called Homberg's sedative salt; it is united with the mineral alkali and forms **BORAX**. It was thought to be an artificial production; but it has been found by Mr. Hoefler in a lake near Sienna, in the great duchy of Hetruria. It acts like an acid, but very feebly. It may be fused without any addition, when it forms a glass like substance, which may be dissolved again by water. It dissolves in spirit of wine, and then the spirit burns with a green flame. It unites with alkalies, earths, and metallic calces. Its specific gravity is 1,480. It is obtained by adding vitriolic acid to a solution of borax; evaporating a little of the water; and the sedative salt will shoot into crystals.

IV. FLOUR ACID. This acid was first prepared by Margraaf; but Scheele first examined it as an acid with precision, and described its peculiar properties; the former directed his attention to the earth, which was volatilized in the process of obtaining it. To prepare it, equal parts of fluor spar and oil of vitriol are distilled in a proper degree of heat, in a glass retort; some water being previously put into the receiver. It exhibits the peculiar phenomenon of a part of its vapors, forming an earthy crust upon the surface of the water. In its smell and volatility, and by causing a precipitate in the solutions of silver and quicksilver in the nitrous acid, it has been supposed a modification of the marine acid; and others suppose it of the vitriolic kind. It unites with alkalies, earths, and some of the metals.

Its use is for etching on glass, prepared and conducted in the same manner, as for etching on copper plates with the nitrous acid.

V. ACID of ARSENIC. This acid was first discovered by Scheele. It is obtained by distilling three parts of dephlogisticated marine acid, over one part of white arsenic in a retort by a red heat; or by dissolving in a retort, two parts of white arsenic in seven parts of spirit of salt; and then pouring upon this three parts and an half of nitrous acid, and distilling off
all

all the liquor to dryness; and at length urging it with a red heat. In both cases the arsenic is found concentrated in the residuum. As it is found in the residuum, it is in a solid and concrete state; it may however be dissolved in twice its weight of water, and brought into a liquid form; which by evaporation will become solid again. When this is sublimed, it re-assumes the nature of white arsenic; and by the addition of phlogiston, the regulus of arsenic.

VI. ACID SALT of AMBER, or the fuccinous acid. This is obtained from the distillation of amber; by evaporating the phlegm, which comes over during the process, and the salt shoots into crystals. Four pounds of amber yield about nine drachms of it.

VII. MOLYBDENIC ACID. Scheele obtained it by abstracting dilute nitrous acid for five times, using six ounces at each time, from twelve drachms of pulverised molybdena. There remained at last a powder as white as chalk, which weighed six drachms and a half; was perfectly soluble in twenty times its weight of water; and gave it an acid, and almost metallic taste. And

VIII. TUNGSTENIC ACID. To obtain this, one part of the pulverised tungsten, is mixed with four of salt of tartar; and fused in an iron crucible. The fused

mass being poured out, is then dissolved in ten times its quantity of boiling water; and the solution is decanted clear from the powder that settles at the bottom. After this the alkaline liquor is precipitated with nitrous acid, and hence is obtained the earth of tungsten, which possesses all the properties of an acid.

Of VEGETABLE ACIDS.

VEGETABLE acids are generally liquid, and contain a considerable portion of mucilaginous matter; consequently they do not possess so great a degree of acrimony and sharpness, as the mineral acids. It is very probable, that the base of all the acids is one identical substance; and though there may appear specific differences among them, those may arise from particular modifications. The French suppose this acidifying principle to be the oxygène, or base of dephlogisticated air; Mr. Kirwan supposes it to be fixed air; but it appears to me to be simple elementary fire. But at present, as this is merely conjectural, we will proceed to the enumeration of the vegetable acids.

I. ACID of LEMONS. This is obtained by the pressure of the pulpy part of the fruit; which is filtered after a previous and spontaneous clarification; and kept in a cool place in glass bottles covered with
fine

fine expressed oil. To obtain the pure acid, the juice must be saturated with chalk while boiling. Upon this the precipitated earthy sediment is washed; covered with water, and mixed with as much oil of vitriol as there has been chalk used for the saturation. Finally, the selenite generated by this means is separated, and the remaining liquor crystallized.

From the investigations of the immortal Scheele, it appears, that in all kinds of fruit, there is either an acid which is entirely the same with the pure acid of lemons; or else another specific acid, which he calls the acid of apples.

II. ACID OF APPLES. In order to separate this in its utmost purity, saturate the juice of apples with fixed alkali; and then pour vinegar of lead upon it, till nothing more is precipitated. After this the precipitate being first washed, pour diluted acid of vitriol upon it, till the mixture exhibits a pure acid taste, without any sweetness. After this the liquor must be separated by filtration. The depurated acid of lemons and apples is discriminated by the following properties, viz. First, The acid of lemons shoots into beautiful crystals; secondly, it does not produce the saccharine acid, by means of nitrous acid; thirdly, it produces no alterations in the solutions of mercury, lead, and silver, in nitrous acid; nor in a diluted

solution of gold; and fifthly, it has a greater affinity to calcareous earth, than the acid of apples.

The ACID of APPLES. First, cannot be made to crystallize, and is always deliquescent; secondly, with nitrous acid, it forms acid of sugar; thirdly, It precipitates nitrous solutions of mercury, lead, and silver, and a diluted solution of gold; and fourthly, lime combined with acid of apples, is more soluble in water, than when it is combined with the acid of lemons.

III. ACID of SORREL. The juice of sorrel after the fœces have settled, must be evaporated till only one third remains; and then passed through a flannel bag. It is then evaporated again till a pellicle appears on the surface; when it is poured into a glass; a little oil of olive put on its surface; and then set by in a cool place, till the crystals shoot. These crystals contain a portion of alkali. The pure acid is obtained by distillation; as fire expels it from all its combinations; or, with a solution of sugar of lead; the acid of which, unites with the alkali; while the acid of sorrel unites with the lead; which may be precipitated by the vitriolic acid, and then the acid of sorrel, will crystallize in a pure state.

This

This acid is not essentially different from the acid of fugar, which is a factitious preparation obtained by abstracting nitrous acid from fugar. Scheele first discovered this analogy, by saturating cold water with the acid of fugar; and adding to this solution some lixivium of tartar, drop by drop; during the effervescence small crystals formed, which were found to be genuine salt of wood-sorrel. Klaproth, of Berlin, corroborated Scheele, by means of a very striking and curious experiment. He precipitated a nitrous solution of mercury with acid of wood-sorrel, neutralized by vegetable alkali. The white precipitate well washed and dried, and gently heated in a tea spoon; produced a fulminating noise not inferior to that of fulminating gold. Acid of fugar perfectly neutralized by vegetable alkali produced the same precipitate, which on exposure to heat, exhibited the same fulminating power.

IV. ACID OF TARTAR. The most simple process for obtaining this acid is as follows; viz. one pound of cream of tartar, boiled in five or six pounds of water; a quarter of a pound of clear and colorless oil of vitriol, is to be added by little and little, when a complete solution is obtained. If the coc-tion be continued, all the vitriolated tartar is precipitated. When the liquor is evaporated to one half, it is to be filtered; and if upon farther evaporation,
any

any thing more is precipitated, it must be filtered again. The clear liquor is then to be reduced to the consistence of a syrup, and set in a temperate, but rather warm place; when very fine crystals will be formed; and as much acid will be obtained as is equal to half the weight of the cream of tartar employed. It unites with alkalies, and forms different neutral salts, and with some of the metals.

V. ACID of BENZOIN. This is obtained from the resinous substance, called benzoïn. The process is from Scheele as follows, viz. four ounces of fresh burnt lime are flaked with a little water. It is then, with one pound of benzoïn, reduced to a fine powder, and with eight of water thrown into a pewter kettle; and the whole boiled for half an hour, over a gentle fire, continually stirring. After this the solution is filtered; what remains on the filtre is boiled once or twice more with eight pounds of water; and lastly, the residuum washed as much as possible with hot water. The two solutions are boiled down to two pounds, and after being filtered very clear, poured into a glass vessel. A quantity of marine acid is then added to the liquor till it begins to taste sourish; immediately upon which the flowers of benjamin are precipitated, and the whole mixture acquires an agreeable flavor. The flowers are deprived of all the adhering acid, by washing in cold water.

water. From one pound of benjamin, fourteen drachms of this acid may be obtained.

VI. ACETOUS ACID, or VINEGAR. It is produced by continuing the vinous fermentation. It is concentrated by freezing. The strongest which is called RADICAL VINEGAR, is obtained by decomposing acetous neutral salts, by means of the vitriolic acid; which having a stronger affinity to their bases, extricates the vinegar in the form of a very penetrating vapor. It unites with alkalies and most of the metals.

To which may be added the ACID of GALLS, discovered by Scheele; the ACID of CORK, discovered by M. Brugnatelli; the ACID of CAMPHOR, discovered by M. Rosegarten; and that of GUMS, and MUCILAGES, discovered by Westrumb; all which yield the ACID of SUGAR, by treating with nitrous acid, so that it is probable they are only different modifications of the same acid.

Of ANIMAL ACIDS.

I. ACID of ANTS. It is obtained in the following manner. Upon a great quantity of ants contained in a retort; water is poured, which is then drawn off till nearly half, and yields an acidulous wa-

ter, together with a subtle ethereal oil. What remains in the retort is put into a linen bag, and all the liquor pressed out. This contains the greatest part of the acid of the ants, together with an unguinous oil, which must be separated from it. To obtain it in a pure state, the expressed liquor must be poured again into a retort, and the aqueous part drawn from it by a gentle fire; and as soon as any acid drops make their appearance, the whole must be received in a separate receiver, and the distillation continued till an empyreumatic smell is perceived. To procure it in a concentrated state, the whole acid liquor must be saturated with an alkali; then filter it, evaporate, and distil it again, with half its quantity of oil of vitriol. This acid resembles vinegar in most of its properties, but differs from it in forming crystals, with magnesia, iron, and zinc. It is probable that the acids of silk-worms, bees, wasps, &c. are of the same nature as the acid of ants, and therefore they are not spoken of as specific differences.

II. NITROUS ACID. This is the produce of animal matters, undergone the putrefactive fermentation. It is obtained by distilling vitriolic acid over saltpetre, and condensing the vapor in a receiver. It is called AQUA FORTIS.

III. Acid

III. ACID of FAT. Obtained by repeated distillations of animal fat.

IV. ACID of PHOSPHORUS. This is procured by dissolving calcined bones in nitrous acid, and precipitating the calcareous earth with the vitriolic acid. The liquor is to be filtered to separate the selenite, and consists of the acid of phosphorus and nitrous acid. The latter may be separated by evaporation; which being continued, leaves the phosphoric acid in a concrete state. This acid distilled with powdered charcoal, yields phosphorus. What is called the perlate acid, appears only a modification of the phosphoric.

V. ACID of PRUSSIAN BLUE. To obtain which, saturate perfectly caustic fixed alkali, by boiling it repeatedly on fresh portions of Prussian blue. Filter and mix highly rectified spirit of wine, which throws down the proper salt of the lixivium in white flocculi. These are separated by filtration, and all the matter soluble in spirit of wine is extracted. A solution of this salt in water is of a bright yellow color; does not shew the least vestige of iron on the addition of an acid; and precipitates that metal of a beautiful blue color.

VI. ACID

VI. ACID of SUGAR of MILK. Common whey clarified with the whites of eggs, and evaporated, yields crystals. These crystals according to Scheele contain an acid sui generis.

Of EMPYREUMATIC ACIDS.

WHEN acids are produced by the action of fire, they will always become empyreumatic; on account of their oleaginous parts being decomposed and destroyed; but on being purified they exhibit a great resemblance to vinegar. Of this kind is the vinegar of wood, which is obtained in the small, by a dry distillation of wood in an iron retort. After a rectification, it may be concentrated like distilled vinegar by an union with fixed alkalies; and by being expelled by the vitriolic acid, obtained in a very pure state.

As most vegetables, by being distilled in an open fire, yield empyreumatic acids; if there be any specific differences in them, they will form a very numerous class.

Fixed air possesses all the properties of an acid; but as it is generally treated of among the gases, it is now referred to that class.

Aqua

Aqua regia, which is classed among the acids, is a compound of the marine and nitrous acids. It dissolves gold in consequence of the nitrous acid dephlogisticating the marine, so that the latter is always in a very concentrated state.

Of ALKALIES.

THE general properties of alkalies, are, first, They change the blue color of vegetables into a green. Syrup of violets is a good test, but the best is brasil wood, macerated in water; which is tinged red; but on the application of an alkali, assumes a blue color; one grain of mineral alkali tinges 4,295 grains of the test water.

Secondly, They unite with acids and form neutral salts, and

Thirdly, In their natural state they are combined with fixed air, when they are called mild; to distinguish them from that state produced by art, which is called caustic; which consists of depriving them of their fixed air, by boiling in water with quick lime; the lime has a superior attraction for fixed air, therefore deprives the alkali of it, so that on the application of an acid no effervescence ensues, which is always the case when the alkalies are in a mild state.

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The crystals of the alkalies depend on their union with fixed air or water.

Alkalies are divided into three classes, viz. first, MINERAL, or FOSSIL; secondly, VEGETABLE; and thirdly, VOLATILE.

I. Of MINERAL, or FOSSIL ALKALI,

AS this salt is not produced in the animal or vegetable kingdom, it is called mineral or fossil. It is found native in Hungary, Egypt, Syria, Persia, &c. but is in general obtained by burning plants, which grow near the sea, particularly kali, a plant which grows plentifully on some parts of the Spanish coasts. It is imported under the name of soda, or barilla, and is the natron of the ancients. In its mild state, it forms regular crystals, which dissolve in 2,5 times its weight in water, in the temperature of 60. 100 parts according to Bergman contain 20 of alkali, 16 of fixed air, and 64 of water.

II. Of VEGETABLE ALKALI.

IT is obtained from the combustion of all vegetables, which grow beyond the sea mark, by the lixiviation of their ashes. In its impure state, it is called POT-ASH; but when it is purified by solution
and

and filtration, it is called PEARL ASH. Tartar burnt in an open fire, yields the same alkali. 100 parts of which contain 23 of fixed air, 5 of water, 2 of earth, and 70 of alkali.

Though these alkalies agree in some general characters, yet they have their specific differences.

I. MINERAL ALKALI crystallizes, but the vegetable alkali never does, in any regular form.

II. MINERAL ALKALI on exposure to air, loses its water of crystallization, and is reduced to a fine white powder; vegetable alkali, on the contrary, attracts moisture from the air, liquifies, and is then called OIL of TARTAR. And

III. The mineral alkali united with the different acids forms neutral salts, easily distinguishable from those with the base of vegetable alkali.

III. Of VOLATILE ALKALI.

This alkali is known by its penetrating smell. Its natural state is vaporous. It is obtained by distillation of animal and vegetable substances, and by the putrefaction of the same. One hundred parts of concrete volatile alkali, contain twelve parts of water,

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ter,

ter, forty-five of fixed air, and forty-three of pure alkali.

This alkali appears in six different forms, viz. First, Vapor. This is its pure and original state. Secondly, In a clear transparent liquid form. In this state it is mixed with water, and deprived of its fixed air by quick lime. This is called SPIRIT of SAL AMMONIAC with quick lime. Thirdly, As a nearly transparent liquor; this differs from the former in having a small portion of fixed air contained in it, and is called SPIRIT ^{of} SAL ~~of~~ AMMONIAC. Fourthly, In a solid form, called VOLATILE SALT from SAL AMMONIAC. It is in union with a considerable quantity of fixed air. Fifthly, It appears as a liquid of a brown color, with a peculiar animal smell. This is called SPIRIT of HARTSHORN, and owes its color and smell to an animal oil mixed with it; and sixthly, of a solid form. This is rendered solid by fixed air, and contains a considerable quantity of empyreumatic oil. It is called VOLATILE SALT of HARTSHORN, and is the most impure of all the preparations.

Of NEUTRAL SALTS.

THERE are three species of neutral salts. First, With an alkaline base; secondly, with an earthy base; and thirdly, with a metallic base. They result from a perfect saturation of an acid, with either an alkali, an earth, or a metallic calx. In this state they form various crystals, which dissolved in water, and poured into a tincture of the blue flowers of vegetables, produce neither a red nor a green color, hence they are called neutral salts.

Acids can dissolve two or three bases, and form apparently a simple neutral salt. This state can only be detected by chemical analysis.

The class of neutral salts is so extensive, that to give a full enumeration of them is incompatible with our present plan; but we will mention the combinations of the three principal acids, viz. the vitriolic, the marine, and the nitrous.

I. VITRIOLIC ACID *with an* ALKALINE BASE.

1. *With Mineral Alkali forms Glauber's Salt.*

These crystals, according to Bergman, contain in one hundred parts, fifteen pure mineral alkali, and twenty-

twenty-seven of vitriolic acid, and fifty-eight of water.

II. *With vegetable Alkali, forms vitriolated Tartar.*

These crystals, according to Bergman, contain in one hundred parts, fifty-two of pure alkali, forty of vitriolic acid, and eight of water.

III. *With volatile Alkali, forms vitriolic Ammoniac.*

THIS contains in one hundred parts, forty-two of acid, forty of alkali, and eighteen of water.

II. VITRIOLIC ACID *with* EARTHY BASES.

I. *With Clay, forms Alum.*

ONE hundred parts, contain eighteen of clay, thirty-eight vitriolic acid, and forty-four of water.

II. *With Lime, forms Gypsum.*

One hundred parts of gypsum, contain thirty-two of lime, forty-six acid, and twenty-two of water.

III. *With Magnesia, forms Epsom Salt.*

ONE hundred parts, contain nineteen of magnesia, thirty-three of acid, and forty-eight of water.

IV. *With Barytes, forms Baroselenite.*

ONE hundred parts, contain sixty-seven of earth, and thirty-three of acid and water.

III. VITRIOLIC ACID *with* METALLIC CALCES.

AS all the neutral salts with metallic bases, have not as yet been sufficiently investigated; we shall mention only those which are most connected with the arts.

I. *With Copper, forms blue Vitriol.*

ONE hundred parts of blue vitriol, contain twenty-six of copper, forty-six of vitriolic acid, and twenty-eight of water.

II. *With Iron, forms green Vitriol.*

ONE hundred parts of which, contain twenty-three of iron, thirty-nine of vitriolic acid, and thirty-eight of water.

III. *With Zinc, forms white Vitriol.*

ONE hundred parts, contain twenty of zinc, forty of vitriolic acid, and forty of water.

I. MARINE ACID *with an* ALKALINE BASE.

I. *With mineral Alkali, forms common Salt.*

ONE hundred parts, contain forty-two of alkali, fifty-two of acid, and six of water.

II. *With Vegetable Alkali, forms digestive Salt of Sylvius.*

ONE hundred parts, contain sixty-one of alkali, thirty-one of acid, and eight of water.

III. *With volatile Alkali, forms common sal Ammoniac.*

ONE hundred parts, contain forty of alkali, fifty-two of acid, and eight of water.

II. MARINE ACID *with* EARTHY BASES,
forms CHRYSTALS *very* DELIQUESCENT.

I. *The Crystals form Marine Acid and Lime, called
Marine Selenite.*

CONTAIN in one hundred parts, forty-four of lime, thirty-one of acid, and twenty-five of water.

II. *The Crystals from Marine Acid and Magnesia,
called Marine Epsom.*

CONTAIN in one hundred parts, forty-one of magnesia, thirty-four of acid, and twenty-five of Water.

III. *Marine Baroselenite.*

Is the marine acid united with barytes. Forms large foliated crystals not as yet examined.

IV. *With Clay, Marine Alum deliquescent, not examined.*

METALLIC salts prepared with the marine acid, do not for the most part assume a crystalline form, and those which do, are in general deliquescent.

I. NITROUS ACID, *with an* ALKALINE BASE.

I. *With Mineral Alkali, forms cubic Nitre.*

ONE hundred parts contain twenty-nine of acid, fifty of alkali, and twenty-one of water.

II. *With Vegetable Alkali, forms common Nitre.*

ONE hundred parts contain thirty of acid, sixty-three of alkali, and seven of water.

III. *With Volatile Alkali, forms nitrous Ammoniac.*

ONE hundred parts contain forty-six of acid, forty of alkali, and fourteen of water.

II. NITROUS ACID *with* EARTHY BASES.

I. *With Lime forms nitrous Selenite.*

ONE hundred parts contain thirty-three of acid, thirty-two of lime, and thirty-five of water.

II. *With Magnesia, forms nitrous Epsom.*

ONE hundred parts contain thirty-six of acid, twenty-seven of magnesia, and thirty-seven of water.

III. *With Barytes, forms barytic Nitre.*

IT crystallizes, but the crystals have not been examined.

IV. *With Clay, forms alunitic Nitre.*

THIS cannot be crystallized, but forms a gummy mass.

From the nitrous acid, and the different metals, arise metallic nitrous salts; of which a few only crystallize, and most of them deliquesce on exposure to the air.

When there is a super-abundance of acid in compound salts, they are called superacidated salts, as in alum, &c. and when the alkali predominates, they are called subacidated salts, as in borax, &c.

One hundred parts of pure mineral alkali, require to saturate them, one hundred and seventy-seven parts of vitriolic acid, one hundred and thirty-five and a half of nitrous acid, and one hundred and twenty-five of marine acid.

One hundred parts of pure vegetable alkali, require to saturate them, seventy-eight and a half of vitriolic acid, sixty-four of nitrous acid, and fifty-one and a half of marine acid.

One hundred parts of vitriolic acid, require to saturate them, one hundred and twenty-seven and a half of pure vegetable alkali, fifty-six and a half of mineral alkali, and forty-two of volatile alkali.

II. *Of*

II. *Of* INFLAMMABLE BODIES.

WE understand by the term, inflammable bodies; substances which are capable of taking fire and bursting out into flame; from which particularities they are easily distinguished from all other bodies.

This class comprehends seven genera, viz. First, INFLAMMABLE AIR, secondly, ALCOHOL; thirdly, OILS; fourthly, SULPHUR; fifthly, CHARCOAL; sixthly, PYROPHORI; and seventhly, METALS.

In giving an explanation of the circumstances, which take place during the inflammation of bodies; it must be observed; First, That all inflammable substances, contain one identical principle, called phlogiston; and secondly, that no inflammation can take place in combustible bodies, unless they be exposed to atmospheric air; and then the inflammation in a determinate quantity, can only be carried on to a certain point, dependent on its purity. For the atmosphere being composed of different vapors, they do not all contribute to promote this process; and however various they may be, only one of its constituent parts, viz. empyreal air, has the least power, either in exciting, or continuing inflammation; the other parts unconnected with that principle, would effectually

effectually destroy it. This empyreal air is a compound body; formed of its radicle and elementary fire.

These circumstances being premised, we will proceed to explain the phenomenon of inflammation.

Inflammation is a decomposition, effected by a double elective attraction. But it must be previously observed, that combustible bodies retain their phlogiston, or principle of inflammability, with different degrees of cohesion; some parting with it in the temperature of the atmosphere, as the pyrophori; and others requiring the application of heat ab extra, before inflammation can be effected. Now, in the latter case, I look upon the heat lessening the attraction of cohesion between the parts, as reducing the combustible bodies into a state similar to that of pyrophorus; at which point, the radicle of the dephlogisticated air, having a stronger attraction for the phlogiston of the inflammable body, than for the elementary fire, with which it is united; breaks through its union, and combines with the phlogiston, setting at liberty the particles of elementary fire, which escape into the air. The radicle of the empyreal air and the phlogiston, form a compound, which is absorbed by the burning body. This compound is determined by the temperature

temperature at which the union is formed, if it be low, the result will be fixed air; but if at a high temperature, it will be water.

The intensity of heat thus produced, is divided into five degrees, reduced to the scale of Fahrenheit's thermometer. The first is called Digestory. It begins at the 34th degree of that scale, and reaches to the 94th. At this degree the putrefaction of animals and fermentation of vegetables begin. It is employed for preparing tinctures, elixirs, lac varnishes, &c. The second, is called DISTILLATORY, begins at the 94° and extends to 212°. This is used for the distillation of spirit of wine, water, ethereal oils, as well as for the rectification of vegetable acids, as for the marine and nitrous; and for the preparation of varnish, for the use of painters. Third, is called SUBLIMATORY. It begins at 212° and reaches to 600°. Lead and tin melt; fixed alkaline salts are brought into fusion; oil of vitriol is rectified, and the different kinds of sublimation are performed. The vessels in these operations are brought to a dull red heat. The fourth degree, is called the FUSORY. It begins at the 600° and ends at the 1600°, or at that at which iron melts. At this degree, gold and silver are cupelled; ores are fluxed; pottery and porcelain baked; limestone converted into lime, and glass fused. At the highest point of
this

this degree all bodies give out a white heat. The heat produced by concave mirrors and convex lenses is considered as the fifth degree; by which wood may be burnt to a coal, even under water, and vitrescent stones begin to melt. The reason why such uncommon effects are produced by the sun's rays, is, that the elementary matter of fire acts in a state of the greatest purity possible; while the fire produced by means of the combustible matters of our earth, is prevented acting with its full power by other matters extricated at the same time, such as air, water, &c.

Though the class of inflammable bodies, comprehends only seven genera, yet from various modifications they branch out into a considerable number of distinct species, and may be thus arranged, viz.

I. *Inflammable Air*, will be more particularly noticed among the permanent gases.

II. *Alcohol*. Its compounds are,

I. *Dulcified Spirit of Vitriol*; and II. *Vitriolic Æther*, in union with different portions of vitriolic acid.

III. *Sweet Spirit of Nitre*; and IV. *Nitrous Æther*, in union with different portions of nitrous acid.

V. *Sweet Spirit of Salt*; and VI. *Marine Æther*, in union with different portions of marine acid.

VII. *Acce-*

VII. *Acetous Æther*, united to vinegar.

VIII. *Lignic Æther*, united to vinegar of wood.

IX. *Oxaline Æther*, united to the salt of wood for-
rel.

X. *Sebaceous Æther*, united to the acid of fat.

XI. *Phosphoric Æther*, united to the acid of phos.

XII. *Formic Æther*, united to the acid of ants. And

XIII. *Sweet Spirit of Sal Ammoniac*, united to vo-
latile sal ammoniac.

III. OILS, divided into unctuous, essential, fossil,
and animal.

I. *Unctuous Oils*, called also *unguinous*, expressed,
Bland, *Fat*, or *Grease*. These are oils of sweet and
bitter almonds, olives, palm, &c. Their combina-
tions, are soaps, acid, alkaline, and metallic, and bal-
sams of sulphur, or sulphurated oils.

II. *Essential Oils*, called also *ethereal* or *aromatic*
Oil, *Balsam* and *Resin*. These are soluble in alcohol.

III. *Fossil Oils*, as *naphtha*, *petroleum*, *Barbadoes*
tar, *jet*, *amber*, *pit coal*, *asphaltum*, *Jews pitch*, *bi-*
tumen, &c. and

IV. Ani-

IV. *Animal*, Dippel's oil, *excrementitious*, ambergrise, castor, musk, &c.

IV. SULPHUR. Its compounds are,

I. *Liver of Sulphur*, united to an alkali.

II. *Sulphurated Metals*.

III. *Hepatic Gas*, united with phlogiston and water.

IV. *Phosphoric Sulphur*.

V. *Phosphoric Gas*. And

VI. *Sugar, Honey, Manna, or oxaline Sulphur*.

V. CHARCOAL. Charred Vegetables, Linen or Tinder, charred Oil, Lamp Black, Coaks or Cinders, animal Charcoal.

I. *Plumbago*, composed of inflammable and fixed airs.

II. *Diamond*.

VI. PYROPHORI. HOMBERG'S PYROPHORUS, composed of Sugar and Alum calcined. Black Wad, Hay undergoing the acetous

Fermentation, Ignis Fatuus, and other Meteors, &c. &c. And

VII. METALS. As Iron, Zinc, Antimony, &c. used in giving different Colors, in Fire-works.

Alcohol is the produce of the fermentation of sugar, malt, &c. and is the most intricate process connected with chemistry. It is divided into three species, viz. the vinous, the acetous, and the putrefactive. The first production of this process, is ardent spirit, spirit of wine, or alcohol. The second, vinegar; and the third volatile alkali; so that the different species are distinctly marked. The vinous and acetous fermentations are attended by a brisk intestine motion and extrication, of a considerable quantity of fixed air. It is promoted by warmth, but not to exceed the heat of the human body; and requires exposure to air. The putrefactive fermentation takes place principally in organic matters.

The constituent parts of alcohol, appear to be, phlogiston, elementary fire, and a small portion of water. The æthers contain the same principles, united to particular acids as their bases. The general principle of oils, resins, bitumens, charcoal, &c. is phlogiston. Sulphur is composed of the vitriolic acid, and that principle.

III. *Of METALS.*

WE must refer the reader to the books treating on those particular subjects.

IV. *Of EARTHS.*

EARTHS have always been looked upon as primitive principles, contained as constituent parts of most bodies. Chemical analysis has discovered five species, whose characters are permanently distinct; and incapable of being changed, by any means yet employed. They are, first, CALCAREOUS. Secondly, PONDEROUS. Thirdly, MAGNESIAN, or MURIATIC. Fourthly, ARGILLACEOUS; and Fifthly, SILICEOUS.

I. *Of CALCAREOUS EARTH.*

CHEMISTS have given this name in general to all earths and stones, which by being burnt, acquire the properties of quick-lime. The characters of which are, first, its specific gravity is about 2,3; it has a hot burning taste; acts powerfully on animal substances; and imparts great heat on the application of water. Secondly, At the temperature of 60°, it requires six hundred and eighty times
its

its weight of water to dissolve it. Thirdly, It unites with acids, and except with the vitriolic, forms with them deliquescent salts; and fourthly, it is infusible in any heat of a furnace; yet acts as a powerful flux on the other earths. Fixed alkalies have scarcely any effect upon it; but it is easily brought into fusion by borax or microcosmic salt. Fused with calx of iron it forms a black mass of a metallic appearance; with calx of copper a red colored mass; with calces of lead, zinc, tin, and antimony, a yellow glass, and with calx of bismuth a greenish glass. In its natural state, it constitutes marble, limestone, chalk, spars, &c. and when united with a small portion of vitriolic acid, selenite, gypsum, plaster of paris, alabaster, &c.

II. OF PONDEROUS EARTH.

THIS earth is called barytes. It is united with either the vitriolic acid or fixed air. It is separated from the first by calcining it in a red heat with oil or powdered charcoal; and afteredulcoration it is found in a pure state, which perfectly resembles lime in taste, but requires 900 times its weight of water to dissolve it, at the temperature of 60° . Or it may be separated from the vitriolic acid by calcining it with twice its weight of fixed alkali, which unites with the acid, and forms vitriolated tartar; that is dissolved by adding boiling water, so that the earth is left disengaged

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gaged. When it is found united with fixed air; the air cannot be dissipated by calcination; and the only method to separate it is, by dissolving in the marine or nitrous acid, and precipitating it with caustic alkali. When dissolved in marine or nitrous acid, and evaporated; it yields crystals, which do not deliquesce; and is precipitable from those solutions by the Prussian alkali; a property which distinguishes it from all the other earths. It decomposes vitriolated tartar, an effect which no other earth can operate. In the dry way, it acts and is acted upon nearly as calcareous earth, but is more fusible by the mineral alkali. Its specific gravity exceeds 4,000.

III. MURIATIC EARTH, *or* MAGNESIA.

ITS specific gravity is about 2,33; it requires about six hundred and ninety-two times its weight of water to dissolve it, in the temperature of the air. It combines with acids; the vitriolic separates it from the nitrous and marine; the precipitate forms Epsom salt, which is very bitter and soluble in its own weight of water. It neither melts nor burns to lime in the strongest heat; but loses considerably of its weight, partly by evaporation, and partly by the loss of fixed air. It does not vitrify with any of the simple earths singly, except lime; but it is brought into fusion by borax or microcosmic salt; but

but is not affected by fixed alkalies, or the calces of lead.

IV. ARGILLACEOUS EARTH, *or* EARTH *of* ALUM.

THIS is called argill, its specific gravity does not exceed 2,000. It is very diffusible, but not more soluble in water than pure magnesia. It combines with the nitrous and marine acids, from which it is separable by the vitriolic, and forms alum. It is not precipitable from those acids by the acid of sugar; which distinguishes it from the foregoing earths; all of which, except the ponderous united with the vitriolic acid, are precipitable by the acid of sugar; though, if there be an excess of mineral acid, the precipitate is not always apparent, till a part of the liquor be evaporated. The strongest heat does not convert it into quick lime, nor fuse it; either single or with siliceous earth; but with the calcareous it readily runs into fusion. Fixed alkalies do not promote its fusion, but borax and microcosmic salt dissolve it. It is affected something less by the calces of lead, than calcareous earth.

V. SILICEOUS EARTH.

THIS is called crystalline, or vitriable earth, as it is that of which glass is generally formed. Its specific gravity is greater than all the simple earths except barytes; being 2,65. In the temperature of the atmosphere, only one part of this earth can be dissolved in ten thousand parts of water; but in a higher temperature it is more soluble. None of the acids except the fluor affects it; but that will dissolve a considerable portion of it. Caustic fixed alkalies in a liquid state, will take up from 1-10 to 1-6 of their weight. It is of itself infusible in the strongest heat; neither does argillaceous nor muriatic earth assist its fusion; and the calcareous is somewhat doubtful. Fixed alkalies bring it into fusion, and will melt double their weight of it; borax affects it slightly, and microcosmic salt scarcely any. The calx of lead will melt from 1-3 to 1-2 its weight of it.

In consequence of the calcareous, magnesian, ponderous, and argillaceous earths, being combinable with all acids, they are frequently called absorbent earths.

From the combination of different proportions of these five simple earths; arises all that amazing variety of species, which is found in the fossil kingdom.

V. *Of* AIR.

Mr. BOYLE and other philosophers, considered the several vapors obtained from certain substances by artificial processes, as atmospherical air; and applied the term to every permanently elastic vapor; hence factitious, fixed, or fixable air, to which later experimenters have added inflammable air, nitrous air, &c. These terms lead to an opinion that such vapors are different modifications of the atmosphere; but as that is not the case, retaining them must be a continual source of error; therefore we shall follow Van Helmont, in comprehending such permanent vapors, as are obtained by any chemical process, under the general term gas.

Chemical analysis teaches us, that the atmosphere is an heterogeneous vapor, composed of fixed, phlogisticated, and empyreal gases, besides various other soluble matters. Its general properties are, first, its specific gravity is to that of water as 1 to 850. Secondly, It is capable of great compression and expansion. Thirdly, It is a principal agent in all chemical processes, particularly in combustion, and the calcination of metals. Fourthly, It is indispensable for the support of animal and vegetable life. Fifthly, It is perfectly soluble in water; and sixthly, it is con-

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tained

tained in most substances in a solid state, from which it may be extracted by the air-pump.

EMPYREAL GAS.

THIS is obtained by heat, from calcined mercury, red precipitate, from minium, moistened with nitrous acid; lunar nitre; nitres with alkaline and earthy bases, &c. leaves of plants, raw silk, and other organized substances, immersed in water, impregnated with aerial acid, and exposed to the sun's rays, likewise produce it.

It is heavier than common air, the only vapor which can support life, or maintain combustion; and is three times as effectual in that process as common air. United with inflammable gas at a low temperature, it forms aerial acid; but with a red heat, water.

MEPHITIS *or* MEPHITIC GAS,

SO called, because it is adverse to the animal frame. This gas was supposed to be nothing more than air, altered by phlogistic processes; and was therefore called phlogisticated gas. But it is now proved to exist ready formed in the atmosphere, and is developed in proportion as the empyreal gas is absorbed. The usual way of obtaining it in a state
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of purity, is by exposing liver of sulphur in a fluid state, to a certain portion of air; the liver of sulphur absorbs the empyreal gas, and leaves the pure mephitis behind. It has been discovered in the air bladders of carp, and may be collected by breaking them under vessels filled with water.

Mephitis has neither taste nor smell, it is lighter than atmospheric air; it does not redden the tincture of litmus, nor precipitate lime from lime-water. Neither water, earths, nor acids, have any visible action upon it. Mr. Cavendish has discovered that three parts of mephitis and seven parts of empyreal gas, exposed to the passage of the electrical spark, are gradually condensed, and produces nitrous acid. Berthollet in decomposing volatile alkali, found it to consist of five parts of mephitis, and one of inflammable air. As animal matters contain a considerable portion of it, which is extricated during putrefaction; volatile alkali in a great quantity must be formed during that process.

NITROUS GAS.

THIS is obtained from the action of nitrous acid upon metals, oils, &c.

It extinguishes flame, deprives animals of life, is neither acid nor alkaline; nor is it altered by pure water. It is composed of mephitic, phlogiston, and empyreal gas. When united with air, a diminution is produced in proportion to the purity of it; hence it is used as a test to determine the salubrity of air at different places.

AERIAL ACID.

IT is obtained from a solution of chalk, mild alkali, marble, &c. in the marine or vitriolic acid.

The properties of aerial acid, are first, it changes the blue color of vegetables into red; secondly, it extinguishes flame, and is highly noxious to animals which breathe it; thirdly, it precipitates lime from lime-water, and renders caustic alkalies mild; fourthly, it is highly antiseptic; and fifthly, water absorbs it, in a considerable quantity.

This vapor constitutes the choak damp of mines.

VITRIOLIC ACID GAS.

IT is the vitriolic acid volatilized by phlogiston. It is very soluble in water, it destroys most vegetables - able

able colors; and when united with alkaline bases, forms neutral salts, different from those formed of the vitriolic acid. It is destructive of animal life.

SPARRY ACID GAS.

IT is obtained from fluor or vitreous spar, by the vitriolic acid. Its principles are not known.

MURIATIC ACID GAS.

IT is obtained by boiling spirit of salt in a retort, placing the neck beneath a vessel filled with mercury. This elastic fluid has a strong and penetrating smell. It extinguishes candles, destroys the life of animals, reddens blue vegetable colors, absorbs the vapors of water which float in the air, and forms with them a white fume, which dissolves in water, and forms marine acid. It causes ice to melt with great rapidity; by reason of the heat it imparts on combination with water. It dissolves camphor. The nature of this gas is not as yet well known.

AERATED MURIATIC GAS.

THIS is obtained with great facility during the action of marine acid on the calx of manganese.

It

It is always of a yellow greenish color, with a strong and penetrating smell. It is not acid; extinguishes flame; and quickly destroys animal life. It destroys the colors of all dyed stuffs, syrup of violets, and tincture of litmus, by turning them to a white. It blanches yellow wax, &c. It decomposes volatile alkali, by depriving it of the inflammable air, and leaves the mephitic. It thickens unguinous oils, calcines metals, not excepting mercury and gold, and dissolves in water, to which it communicates the same properties. It is decomposed by exposure to light, which reduces it to the state of pure muriatic acid.

INFLAMMABLE AIR.

WHEN pure it is the lightest of all the aeriform vapors. It is obtained from a solution of iron in vitriolic acid. It extinguishes fire, is fatal to animal life; inflames on the application of fire, when freely exposed to atmospheric air. United to mephitic it forms volatile alkali; and to dephlogisticated air, water. It is the fire damp of mines.

HEPATIC GAS.

IT is obtained by decomposing liver of sulphur by means of acids. It has a foetid odor, kills animals,

mals, and turns syrup of violets green. Empyreal air precipitates sulphur from it; and it inflames with a reddish blue flame. Water absorbs it, but it is decomposed by exposure to air; and the smoking nitrous acid, and the sulphureous acid decompose it, as well as the gas. Hepatic gas reduces the calces of lead and bismuth. It precipitates muriatic solutions. Mercury and silver decompose it, by separating the sulphur. It is this gas that generally mineralizes all sulphureous waters.

PHOSPHORIC GAS.

IT is obtained by boiling caustic alkali with half its weight of phosphorus; and receiving the vapor in vessels filled with mercury. This gas is foetid, destroys animal life, and takes fire spontaneously by the contact of air. It is a solution of phosphorus in inflammable air.

CARBONACEOUS INFLAMMABLE GAS.

A solution of charcoal in inflammable air. This vapor burns with a blue flame, attended with small white, or reddish sparkles.

ALKA-

ALKALINE GAS.

Is pure volatile Alkali.

THE name of mephitized inflammable air, is given by Fourcroy to the inflammable air of marshes. It is disengaged from standing waters, and in all places where animal matters putrefy in water. It accompanies, precedes, or follows the formation of volatile alkali, which takes place in putrefaction. It is supposed to be formed by mephitic and inflammable air diffused through each other. It burns with a blue flame, and does not detonate with empyreal air without great difficulty.

These gases for experiment are generally collected in cylindrical glasses containing either mercury or water. To ascertain the quantity which any jar will contain in cubic inches; the area must be multiplied by the perpendicular height. Now the area is found by multiplying half the diameter by half the circumference, which is to the diameter as twenty-two to twenty-seven nearly; or still nearer as one hundred to three hundred and fourteen. By way of example, and to use small numbers, and to avoid fractions; we will take the diameter to the circumference as one to three. Suppose the cylinder eighteen inches deep, and its internal diameter exactly

exactly eight inches; its circumference is therefore twenty-four inches; half of which being multiplied by four, which is half the diameter, gives forty-eight for the area; and forty-eight being multiplied by eighteen inches, the depth of the vessel gives the number of square inches of gas contained in the cylinder, viz. eight hundred and sixty-four.

VI. *Of* WATER.

WATER was always looked upon as a simple element; but lately some experiments of Mr. Cavendish, give us reason to believe it is a compound substance, whose constituent parts are inflammable gas, and the base of empyreal gas. But it appears improbable that such immense quantities, which are found on the surface of our earth, should be formed by secondary causes; indeed the production of it by art, seems to depend on circumstances, which can scarcely ever occur in nature, so that water must date with the creation.

The quality of water may be known by the following properties, viz. first, pure water is lighter and more fluid than that which contains heterogeneous substances; secondly, it has no color, smell, nor taste; thirdly, it wets more easily than hard water; and fourthly, soap mixes with it without any decomposition.

Water

Water is susceptible of three states, viz. solidity, fluidity, and vapor. When it becomes ice the air in contact becomes hotter; but as it is reduced to a fluid again, the same air is made considerably colder, than the state of the atmosphere; and when it is converted into vapor, it absorbs heat, and produces cold. It perfectly dissolves in air at 65° of the thermometer; boils at 212° and freezes at 32° . It increases flame, by being decomposed, and furnishing empyreal gas. It has not the least affinity to phlogiston, unguinous oils, fat, resins, and sulphur; but unites imperfectly with essential oils and æther. It is the proper menstruum of salts and caustic earths; and perfectly dissolves gums and mucilages.

Most waters are impregnated with heterogeneous substances, and when they become sensible to the taste they are called mineral waters. The most common impregnations are, first, acids, sometimes in an uncombined state, but most frequently united to earths, alkalies, or metals; secondly, alkalies, sometimes uncombined, but generally in union with aerial or other acids; thirdly, lime, magnesia, terra ponderosa, or clay, most frequently united with acids; fourthly, iron, copper, and manganese. Iron united with fixed gas or vitriolic acid; copper always with the vitriolic acid; and manganese with the marine; and fifthly, sulphur in form of hepatic air, or through
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the medium of an alkali, forming liver of sulphur. Sometimes vitriolated zinc, and arsenic are found.

There are two methods of discovering these impregnations, viz. precipitation and evaporation.

The volatile parts should be expelled by a boiling heat, and collected with a pneumatic apparatus. If aerial acid should be contained, the water previous to boiling will redden the tincture of litmus; or lime-water, will be precipitated either by adding a little of the water, or placing a little lime-water to the action of the expelled vapor. If it should be hepatic air, it will smell like putrid eggs and blacken silver.

I. *By* PRECIPITATION.

IF vitriolic acid be contained in any form, it is detected by a solution of terra ponderosa in marine acid; the vitriolic acid seizes the earth, and falls to the bottom, forming a spathum ponderosum. The marine acid is detected by applying a solution of silver in nitrous acid; the marine acid seizes the silver and falls down in form of a mucilage, insoluble in nitrous acid.

Uncombined alkalies change paper colored with brazil wood to a blue color. Or if a quantity of
sal

sal ammoniac thrown into the water, produce a smell of volatile alkali, the water certainly contains fixed alkali uncombined.

Lime is discovered by acid of sugar; and barytes or terra ponderosa, by vitriolic acid; neutral salts with alkaline bases, are precipitated by highly rectified spirit of wine.

Iron is precipitated blue with prussiated alkali, copper of a brown color, and zinc of a white color, which becomes yellow on exposure to heat, but becomes white again as it cools; or iron may be discovered with tincture of galls, unless it be in a dephlogisticated state, and in union with marine acid, when the tincture of galls produces no effect; but the water is affected in the usual way by the prussiated alkali. For the purpose of discovering whether the iron be dissolved in the vitriolic or marine acid, let a small portion of a solution of terra ponderosa in nitrous acid be added; when, if it throws down a yellow precipitate, and the water loses its inky taste, the iron is dissolved in the vitriolic acid; but if it does not lose that taste, the iron is combined with marine acid. Copper may likewise be detected by the volatile alkali. If manganese be contained, a solution of vegetable alkali poured in the water, forms a white precipitate, which grows black in the fire,

fire, and is neither soluble in nitrous nor vitriolic acid.

Nitrous acid destroys the odor of those waters, which contain liver of sulphur, and separates the sulphur. On the other hand, the vitriolic and marine acids augment the smell, while they separate the sulphur. Solutions of lead, silver, and quicksilver, in nitrous acid; and a solution of corrosive sublimate yield with water thus impregnated a brown or black precipitate, which when dried will burn on a red hot shovel, with a blue flame, and sulphureous smell. If the water be impregnated with hepatic gas, neither the vitriolic nor marine acid augments nor diminishes its odor; nor do they precipitate the sulphur, which is effected by the dephlogisticated nitrous and marine acids only; depriving the water of its odor at the same time. The solutions of lead, silver, and quicksilver, yield no precipitate, unless it contains a considerable quantity of gas; and then the precipitate does not burn with a flame. Silver turns black in it, and deprives it of its offensive odor.

If water contain arsenic, a solution of martial vitriol throws down a black precipitate. Or the water must be boiled down, and the residuum thrown upon live coals; if it smells of garlic, it contains arsenic.

II. *By* EVAPORATION.

BY evaporating a sufficient quantity of water, the salts which it contains appear in the following order. First, aerated lime and siliceous earth fall before the water boils; secondly, gypsum; thirdly, alum; fourthly, vitriolated vegetable alkali; fifthly, martial vitriol; sixthly, common nitre; seventhly, vitriol of copper; eighthly, salited vegetable alkali; ninthly, mineral alkali; tenthly, common salt; eleventhly, vitriol of zinc; twelfthly, vitriolated magnesia; and lastly, deliquescent salts.

The volatile parts must be collected with a pneumatic apparatus, and properly examined and estimated. As there are substances which are decomposed during evaporation, they should be separated previous to that process. These are liver of sulphur and metallic salts. The vitriolic acid of the liver of sulphur, is disengaged during evaporation, and combines with the alkaline substances which may be contained; and the metal of the metallic salts loses its phlogiston, separates from its acid, and forms new combinations. Therefore the sulphur must be precipitated by the nitrous acid, and weighed; and the metallic salts must be ascertained by the prussianated alkali, purified by the nitrous acid. The color of the precipitate shews the metal, and the weight of it, the
quantity

quantity of metallic salt. It must be observed, that various salts are formed, by the union of the re-agents with the substances, previously existing in the water; these are cubic and calcareous nitre, vitriolated tartar, and digestive salt; but these may be ascertained by attending to the quantity of re-agent used and allowing for it. The water is now to be evaporated away; and the residuum weighed. This residuum contains salts, which are soluble in rectified spirit of wine; in cold water, or substances insoluble by either menstruum. Spirit of wine dissolves neutral salts with earthy bases, sedative salt, arsenic, and extractive matter. This solution in spirit of wine, after it is diluted with distilled water, is examined as follows, viz.

I. If precipitants indicate salts with a calcareous basis, the earth must be separated by the acid of sugar, united to an alkali; the precipitate thus obtained gives the quantity of calcareous earth. The salt acquired by crystallization, whether it be nitre or digestive salt, shews with what acid the calcareous earth was combined. In order to separate this salt more accurately, the liquor may be evaporated to dryness, and the soluble part of the residuum extracted with spirit of wine; consequently the digestive salt and cubic nitre remain behind as being insoluble.

II. If, in consequence of the precipitants, a salt with barytic earth be suspected; let a solution of Glauber's

salts, or vitriolated tartar, be poured into the water; the quantity of the precipitate, will shew the quantity of the salt contained in the water. The salt produced by this decomposition, must be separated and examined.

III. If the water contain salts with magnesia for their bases, a portion of fixed alkali must be added to the water, when the magnesia precipitates; and by the crystallization of the salts; or by precipitating them with spirit of wine, it will be seen with what acid the magnesia was combined.

IV. If the water contain sedative salt, it must be evaporated, and the salt will crystallize. This is the only one that is crystallizable and soluble in spirit of wine. Arsenic is detected by a small quantity of volatile liver of sulphur. The liquor must be evaporated to dryness, and the extractive matter is left for examination.

The substances which are soluble in distilled water, may be fixed alkali saturated with fixed air; all the perfect neutral salts, alum, Epsom salt, &c. To discover fixed alkali, let a quantity of Epsom salt be dissolved and added to the water, in a few hours a quantity of magnesia will be precipitated; the quantity of alkali is known by calculating the portion necessary to precipitate the same quantity of magnesia from Epsom salt. If the water contain alum and
Epsom

Epſom ſalt, either with or without other ſalts, the beſt mode to aſcertain their quantity, is to decompoſe them. Let a ſolution of fixed alkali be added drop by drop, till it ceaſe to make the water turbid. Let the precipitate be carefully dried and weighed; and then put it into water ſaturated with fixed air; which will diſſolve the magnesia, but leaves the earth of alum untouched. The difference of weight ſhews the portion of magnesia diſſolved. The ſalt formed by the decomposition is ſeparated by cryſtallization, if the water contain only alum and Epſom ſalt. If Epſom ſalt and Glauber's ſalt be contained in the ſame water, it is impoſſible to ſeparate them by cryſtallization, as they both ſhoot into cryſtals at the ſame time; therefore they muſt be decompoſed, the quantity of either is aſcertained by the weight of the precipitated earth. If Glauber's ſalt, common ſalt, and nitre be contained in water, let a ſolution of terra ponderoſa in nitrous acid be poured into the water; the precipitate dried and weighed, ſhews the quantity of Glauber's ſalt. Into the filtered liquor let a quantity of a ſolution of ſilver in nitrous acid be poured, and the precipitate ſhews the portion of common ſalt; and if theſe precipitates give not the exact weight of the reſiduum diſſolved in cold water, there is reaſon to ſuſpect nitre; the deficiency of weight ſhews the quantity which may be diſcovered likewise by cryſtallization. The ſubſtances remaining, which are not ſoluble either in

spirit of wine or water, are, First, SELENITE; Secondly, IRON; thirdly, SILICEOUS; fourthly, ALUMINOUS; fifthly, MURIATIC; sixthly, CALCAREOUS; and seventhly, HEAVY EARTH.

First, Selenite is extracted by boiling the residuum in 600 times its weight of water which dissolves it, and carries it through a filter. The weight wanting in the residuum shews the quantity of selenite. Or marine acid poured on the residuum dissolves the iron and earths, and leaves the selenite and siliceous earth behind. The selenite is separated from the siliceous earth, by dissolving it in distilled water. Secondly, The selenite being separated by the former method, a little marine acid poured on the residuum, dissolves all the iron and earths, except the siliceous. Thirdly, The iron is discovered by precipitating it in form of Prussian blue, by the prussianated alkali, previously purified by the marine acid. Fourthly, Calcareous earth, in the above solution, by acid of sugar. Fifthly, Barytes by vitriolic acid; and lastly, The magnesia and clay, are precipitated by a mild alkali, and the former is dissolved from the clay by water impregnated with fixed air.

PART I.

OF

MINES AND ORES.

O F

MINES AND ORES.

THE most important branch of chemistry, is metallurgy, which comprehends not only the extraction of metals from their different ores, but likewise the conversion of such metals, either to useful or ornamental purposes. The repositories of ores are called mines, which are in general confined to particular situations, viz. mountainous countries.

Mountains are considered with respect to their structure, as intire, stratified, and confused. The intire mountains are mostly homogeneous; some consist of granite, others of limestone, of a granular or scaly appearance; and some, as in Sweden and Norway, of iron; and the Paris mountain, in the island of Anglesea, of copper ore.

Stratified mountains are either homogeneous or heterogeneous, and are the principal seat of metallic ores. In the homogeneous stratified mountains, the metallic ores run in veins, petrifications are found upon, but not in these mountains.

B

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The heterogeneous mountains, consist of alternate strata of various species of stones, earths, &c. When the stratum consists of limestone, it is of the laminar kind; and if it contain any metallic ore, this is placed between the laminæ. The strata are frequently interrupted by siliceous masses, which are called stops.

These compound mountains contain coal, bitumen, petrifications, and organic impressions, salts calamy, gold in sandy strata, copper and lead ores, pyrites, &c. These lie in the same direction as the strata between which they are placed.

There are mountains analogous to these, which cannot properly be called stratified, as they consist only of three immense masses; the lowest granite, the middle of the argillaceous kind, and the uppermost of limestone. These are in general metalliferous, the ores are found in the second stratum, or between the first and second. They are in veins or bellies, and not strata, running across the other strata in all directions.

Miners distinguish the course of veins with respect to the meridian by the term direction, and with relation to the horizon, by that of inclination. Their direction is either morning, noon, evening or night; by which is meant, as it points towards that division of the compass, where the sun is, at any of those periods of the natural day. They have likewise names
expressive

expressive of their difference, as deep, perpendicular, horizontal, hanging, dilated, rich or poor.

Small veins will sometimes diverge from larger ones, and frequently return into the trunk from whence they issued. These are called slips, and are in general very rich. The superior stratum of earth or stone, immediately in contact with the vein, is its roof; the inferior stratum on which it rests, is the floor.

The terminations of metallic veins are various; first, by a regular diminution, as if, during their soft state, they had been compressed by the superincumbent weight of the superior strata; second, by splitting or ramifying into smaller veins; and third, by terminating abruptly. This termination is caused by new strata running transversely to the other, or by perpendicular fissures, produced by some rupture or derangement of the stratum, through which the vein passes, by which one part has been raised, depressed, or removed aside from the other, most probably by earthquakes. Although veins terminate thus abruptly, they do not entirely cease, but are only disjoined, and are frequently recovered by searching the analogous parts of the opposite side of the deranged stratum.

Mountains consisting of regular strata, called by authors *primæval*, are the principal source of metallic veins, which are seldom if ever found in plains;

the probable reason of which is, that in metalliferous mountains, we have access to the more ancient strata of the earth, which in plains are covered with so many deposited, alluvial, and other strata, that we can seldom if ever reach the former. These veins are never found in diluvial mountains, which are single and detached, though sometimes fragments of ores may be found in them: yet, single and seemingly detached mountains, especially in small islands, have been found metalliferous; but then they are regularly stratified, and small islands themselves are frequently eminent parts of submarine ranges of very extensive mountains.

Mineralogists consider those mountains as most metalliferous, which have a gentle ascent, a moderate height, and a broad basis; the strata of which are nearly horizontal, and not much broken, at least in such mountains the veins are less interrupted, more extended, and consequently more valuable to miners, than those in high, craggy, irregular, and shattered mountains.

The produce of these veins is metallic ores.

Metallic ores are found in two states, viz. first, calciform, and secondly, combined with different extraneous substances, by which they are said to be mineralized. The calciform ores, are metals deprived of their metallizing principle, viz. phlogiston, as the lapis calaminaris, which is an ore of zinc,
and

and the different ochres which are the calces of iron. These ores contain a considerable quantity of fixed air.

The most common mineralizers are sulphur, arsenic, the vitriolic, marine, and phosphoric acids; one species of iron ore appears to be mineralized by the acid of Prussian blue. If the mineralizer be of a saline nature, and the compound soluble in less than twenty times its weight in water, it is generally classed among the salts. There have been some mineralogists who have excluded arsenic as a mineralizer, alleging that it is a metal of itself, and never united to other metals but in a reguline state, therefore that the compound it forms should rather be called an alloy than an ore; but it must be observed, that as metals which are found united either with the calx of arsenic, or its acid, are in a greater or less state of dephlogistication, it ought to be admitted as a mineralizer in the strictest sense of the word; particularly as no such union, without a dephlogistication of the metal united, has ever been exhibited in the mineral kingdom.

Mineralised ores are divided into two classes, viz. first, simple, containing only one metallic substance; and second, compound, which contains two or more metallic substances.

Of the simple and compound ores, four species may be principally discriminated. First, ores con-

taining a metallic substance mineralised by sulphur, as galena, which is composed of lead and sulphur. Secondly, metallic substances mineralised by sulphur and arsenic, as some species of pyrites. Thirdly, ores mineralised by arsenic only, as the white pyrites; and Fourthly, ores mineralised by saline matters, as the native vitriols.

Gold is never found in a mineral state, as it is incapable of forming any union with sulphur, nor can it unite with arsenic but with very great difficulty; and then must be brought into a state of fusion; so that it is always found either native, or invisibly mixed with extraneous matters. It has never been found in a calciform state. There are at present only six species described.

S P E C I E S I.

This is found separate in small lumps, or in visible grains mixed with sand. In this state it is found in France, Africa, Hungary, &c. If 100 pounds of sand contain 24 grains of gold, it is said that the separation is worth attending to. The African gold sand is very productive, 5 pounds of which frequently contain 63 grains of gold, or even more. Attempts have been made in Hungary to extract it, but 10,000 pounds of that sand yielded only from 10 to 12 grains of gold; consequently the working of it was attended with a great loss.

It

It is sometimes found embodied in some matrix, either in a granular, foliated, or ramified form, in stones of the calcareous, but most commonly of the siliceous genus.

S P E C I E S II.

Mixed with yellow or martial Pyrites.

THUS mixed it is found in the mine of Adelfors in Sweden. Cronsted observes that 100 pounds of this ore contain but one ounce of gold, and that it is hardly worth extracting. The pyrites is of a bright yellow colour, close and compact. It has been said that this ore is mineralised by sulphur, by the medium of iron, because it can not be extracted by aqua regia, or amalgamation; but though Bergman inclines to the opinion of the mineralization of gold, yet he is candid enough to own, that the gold when extracted from this ore, being of a granular or angular form, it is doubtful whether it was not rather mixed, than truly combined with the sulphur and iron; more especially as the quantity of gold is so very small, that the sulphur of the pyrites, would not only defend it from the action of the aqua regia, but the nitrous acid becomes so phlogisticated by acting on the pyrites, as not to be able to dephlogisticate the marine, on which depends its power of dissolving gold. Mercury cannot have access to it, therefore cannot extract it.

Pyrites containing gold are likewise found in Switzerland and Hungary; that found in the latter contains five ounces of gold per quintal. The gold mines of Norway are of the same nature as those of Adelfors.

S P E C I E S I I I .

Mixed with arsenical Pyrites.

FOUND at Salzbergh in Tyrole, in mountains of Quartz, which is a species of the filicious genus of earths. The quintal affords only about 25 grains.

S P E C I E S I V .

Mixed with a white, red, or vitreous Silver Ore.

FOUND near Cremnitz, and Schemnitz, in Hungary.

S P E C I E S V .

Mixed with a sulphurated Ore of Silver, Iron, Lead, and Manganese.

LATELY found at Nagaya, in Transylvania. It consists of small dark coloured plates of more or less brightness, inhering in quartz, and a soft whitish substance, which Bergman found to be Manganese. This ore is said to produce ten ounces of gold per quintal, besides a portion of silver,

SPECIES

SPECIES VI.

Mixed with sulphurated Iron and Copper, with Manganese.

THIS is a yellow pyrites, found also at Nagaya in which gold is contained.

In Peru gold is found in a red earth, and a stony matter not well known at present:

PLATINA ORES.

IF there be any ores of platina, they are not at present known.

SILVER ORES.

SILVER is generally extracted from ores of which there are many species.

SPECIES I.

Mineralized by Sulphur, vitreous Silver Ore.

IT is found in large solid lumps, often inhering in the different kinds of earth, of a lamellar, granular, or capillary form, or in a crystallized state; it appears at first of a lead colour, but on exposure to the air, becomes black or grey; its laminæ are flexible, ductile, and sometimes even malleable in some degree, and so soft as easily to be cut with a knife. It
is

is one of the richest of the silver ores. 100 parts containing from 72 to 77 of silver.

It is found in Hungary near Shemnitz, and in Saxony near Freyburgh; particularly in the famous mine of Himmelsfurt.

S P E C I E S II.

Mineralized by a small Portion of Arsenic.

THIS ore is of a striated texture, resembling bismuth, but much harder, of a yellowish white colour, it easily fuses; and if kept in fusion, the arsenic is dissipated, and the silver reduced in nearly a pure state; but it sometimes contains a small portion of iron.

It is found near Quadanal canal, in Spain, and yields about 90 per cent. of silver.

S P E C I E S III.

Mineralized by a large Portion of Arsenic.

So great is the proportion of arsenic in this ore, that were it not easily dissipated, it would not be classed among silver ores, as the quintal contains but from four to six ounces. It is soft, and easily cut, when it exhibits a brilliant metallic appearance.

It is found also at Quadanal canal.

SPECIES

SPECIES IV.

Mineralized by Sulphur and Arsenic. Red Silver Ore

Is a heavy shining substance, either transparent, or opaque, mostly of a crimson, or reddish colour, but sometimes grey or blackish; when scraped, or powdered, always reddish; found in shapeless masses, or crystallized in plated or radiated incrustations, or in matrixes of quartz, flint, &c. In fire it crackles and melts after it has acquired a red heat, with an arsenical smell, and detonates with nitre.

Bergman found 100 grains of it to contain 60 of silver, 27 of arsenic, and 13 of sulphur.

The darkest ores of this species are the richest, and the yellowest are the poorest.

SPECIES V.

Mineralized by Sulphur, and a very small Portion of Arsenic and Iron. Black Silver Ore.

IT is either of a solid and brittle consistence, which distinguishes it from the vitreous ore, and of a glassy appearance in its fracture when recent, or of a looser texture, and sooty or deep black colour, like moss or thin leaves lying on the surface of other silver ores, or of those of lead or cobalt, or in clays, &c. It contains from 25 to 60 per cent. of silver, and is found in Dauphiné, Hungary, and Saxony.

SPECIES

SPECIES VI.

Mineralized by Arsenic, and containing a large Portion of Iron. Arsenical-martial Silver Ore.

MINERALOGISTS do not well agree about the ore to which this denomination belongs. According to Monnet, who has attended to the division of ores most accurately, this ore is a hard substance, and of a compact lamellar, or fibrous texture, the brightest is the poorest in silver; the richest gives only 10 per cent. the poorest 6 or 8. It contains no sulphur, hence Monnet calls it a metallic regulus, not considering that the iron is in a calcined state, which proves that arsenic is a true mineralizer. The arsenic is always predominant.

It is found in Saxony, the Hartz, at Quadanal canal, &c.

SPECIES VII.

Mineralized by Arsenic and Sulphur, with a small Portion of Copper, and a still smaller of Iron. White Silver Ore

IS a heavy, soft, opaque substance, fine grained or scaly, bright and shining in its fractures, of a whitish, steely, or lead colour; sometimes crystallized in pyramidal or cylindrical forms, or resembling moss, or in the form of thin laminæ incrustating other bodies, found in quartz, sparry iron ore, &c. It is very fusible, and contains from 10 to 30 per cent. of silver.

SPECIES

SPECIES VIII.

Mineralized by Arsenic and Sulphur, with a large Portion of Copper, and some Iron. Grey Silver Ore.

THIS is a hard, grey, or dark grey substance, more or less brilliant, sometimes crystallized, but mostly amorphous, and is in fact the grey copper ore hereafter to be mentioned, impregnated with silver, and varies much in its contents; containing from 1 to 12 per cent. of silver, and from 12 to 24 of copper, the remainder being sulphur, arsenic, and a little iron; the richer it is in copper the poorer in silver, and reciprocally. Mr. Monnet remarks, that wherever copper is united to arsenic, silver is also found. It is the commonest of all the silver ores; the grey silver ore of Dal in Sweden, contains also regulus of antimony, but this belongs to the next species.

SPECIES IX.

Mineralized by Arsenic and Sulphur, with Copper, Iron, and Regulus of Antimony. Brown Silver Ore.

It is mostly of a reddish brown, sometimes dark grey, frequently found crystallized in pyramids, but chiefly amorphous. When scraped it appears red; it contains from 1 to 5 per cent. of silver, the greatest part is copper, and the next arsenic.

It is found in Sweden, Germany, and Spain.

SPECIES

SPECIES X.

Mineralized by Sulphur and Arsenic, with Iron and Regulus of Antimony. Plumose Silver Ore.

THIS ore varies with respect to colour, from a dull white, to grey, dark blue, brown, or black. It is found in a capillary form, or like wool, sometimes loose, at other times attached; its filaments are rigid and inflexible, the whiter it is the richer, but it seldom contains even 1 per cent. of silver.

It is found in Saxony.

SPECIES XI.

Mineralized by Sulphur and Arsenic, with Cobalt and Iron. Cobaltic Silver Ore.

IT is distinguished by rose-coloured particles of cobalt, dispersed through a dark, brown, blackish, or grey, and somewhat shining solid mass.

It is found in Saxony, and at Allemont in Dauphiné. It contains about 40 or 50 per cent. of silver, and very little cobalt. The arsenic is in an acid state in union with the cobalt.

SPECIES XII.

Mineralized by Sulphur, with Regulus of Antimony and Barytes. Butter-milk Ore.

It appears in the form of thin pellicles on granular spar.

SPECIES

SPECIES XIII.

Combustible Silver Ore.

THIS is black and brittle, and leaves about 6 per cent. in its ashes. It is a coal in which silver is found.

SPECIES XIV.

Mineralized by the vitriolic and marine Acids with a little Iron, and sometimes with a Mixture of the vitreous Ore. Corneous-Silver Ore.

THIS scarce and valuable ore is of a white, grey, pearly, or yellow, green, brown, purple or black colour; crystallized in a cubic form, sometimes resembling an earth, easily fusible without smoke. It is found in Saxony, Bohemia, St. Marie aux Mines, Siberia and Peru, and should contain 70 per cent. of silver at least, if unconnected with iron.

UNCERTAIN MINERALIZATIONS.

SPECIES XV.

Goose-dung Ore.

THIS is of a greenish colour, mixed with yellow and red; it is said to contain about 6 per cent. of silver. Some think it a mixture of red silver ore, and calx of nickel.

SPECIES XVI.

Foliaceous Silver Ore.

ITS colour is mortdorè, and thought by some to be native silver, by others a mixture of galena, ochre, and silver. It is found in mountain cork, and is so very light that it swims on water, and contains but one ounce per quintal of silver.

SPECIES XVII.

Mineralized by Sulphur, Arsenic, and Bismuth.

SUCH ores have been talked of, but their existence has not as yet been proved.

COPPER ORES.

COPPER Ores may be distinguished in general, by digesting them in fluid volatile alkali, after they have been roasted, which acquires a blue colour from copper; before the mineralizing matters are dissipated by fire, it is possible that arsenic may prevent that effect, or even sulphur, if it be in a sufficient quantity.

There is a great variety of copper ores, as,

SPECIES

SPECIES I.

Calciform Ores, of which there are three Varieties.

I. THIS is found of a red or brown colour, in a loose form, when it is called copper ochre; in general it is moderately hard, yet brittle, sometimes crystallized and transparent, in cubes, prisms, &c. It is found in England, Scotland, Germany, &c. 100 parts contain 73 of copper, 26 of fixed air, and 1 of water.

The brown contains various portions of iron or pyrites, and sometimes sulphurated copper, and affords from 20 to 50 per cent. of copper.

II. Mountain green, or malachite. It has the appearance of green jasper but not quite so hard, as it does not strike fire with steel. It is of a radiated or equable texture, of an oval form in general, about the size of an egg; sometimes it forms capillary filaments. It is found in Norway, Siberia, &c. 100 parts contain 75 of copper, and 25 of aerial acid and water.

III. Mountain blue. This most frequently appears in a loose form, but sometimes indurated, and even crystallized, but it is then mixed with quartz. 100 parts contain about 69 of copper, 29 of aerial acid, and 2 of water.

SPECIES II.

ANALOGOUS to the calciform ores are the cupreous stones, turquoise, and lapis armenus.

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The turquoise is the tooth of an animal penetrated with the blue calx of copper: when heated it loses its colour; it is opaque, of a lamellar texture, and susceptible of a fine polish. Some are of a deep blue, others of a whitish blue, becoming deeper when heated. It is found in Persia and Languedoc.

The lapis armenus, is another blue stone, but does not admit of any polish, consisting of calcareous earth or gypsum, penetrated with a blue calx of copper. It never gives fire with steel.

S P E C I E S III.

Mineralized by Sulphur, with scarce any Iron. Vitreous Copper Ore.

IT is of a red, brown, blue, or violet colour, generally so soft as to be cut with a knife; it is sometimes crystallized in regular figures, and sometimes amorphous, more fusible than pure copper, and found in mines of other copper ores, in lime-stone, spar, quartz, clay, &c. It is the richest of all the copper ores, yielding from 80 to 90 per cent. of copper. The red ores are the poorest.

S P E C I E S IV.

Mineralized by Sulphur, with 20 or 30 per cent. of Iron. Azure Copper Ore.

THIS differs from the foregoing, only in containing more iron. It consists of various shades of blue, or reddish blue; it is as hard, and more brittle, and contains from 40 to 60 per cent. of copper,

from 20 to 30 of iron, and the remainder sulphur; the poorer it is in iron, the richer in copper. This species has been confounded with the indurated mountain blue.

SPECIES V.

*Mineralized by Sulphur, with a large Portion of Iron.
Yellow Copper Ore; yellow Pyrites.*

ITS colour varies, of a yellow, or yellow mixed with red or green, or variegated like a pigeon's neck; it is moderately hard, but does not give fire with steel so readily as other pyrites do; its fracture presents sharp fragments; it is sometimes crystallized, and sometimes amorphous. It occurs in separate masses, and embodied in stones, and is the commonest of all copper ores.

The crystallised sort is the poorest in copper, containing only from 4 to 8 per cent. the greenish yellow contains from 15 to 20 per cent. of copper, the pure yellow contains from 20 to 30 per cent. and is the richest of this species.

SPECIES VI.

*Mineralized by Sulphur and Arsenic, with a little Iron.
Arsenical or grey Copper Ore.*

THIS is of a white, grey, or brown colour, moderately hard, very brittle, sometimes crystallized, often of an indeterminate figure, and very difficult of fusion: it contains from 35 to 60 per cent. of

copper. The brown is the richest in copper; the white and grey contain most arsenic. It frequently contains silver, and if this exceed 1 or 2 per cent. it is called grey silver ore. It is found embodied in all sorts of stones, and mixed with other copper ores, as well as with the ores of other metals.

S P E C I E S VII.

Mineralized by Sulphur and Arsenic, with Zinc and Iron. Blendose Copper Ore.

THIS species has only been met with at Catharineburg, in Bohemia; it is of a brown colour, of a hard, solid, and compact texture. It contains from 18 to 30 per cent. of copper.

S P E C I E S VIII.

Argillaceous Shistose, or flaty Copper Ore.

THIS ore appears to consist of the vitreous copper ore intimately combined with shistus, and not barely dispersed through it in visible particles. It is of a brown or black colour, very heavy, and of a lamellar texture. It is of difficult fusion, yields from 6 to 10 per cent. of copper, and contains a little bitumen, calcareous earth, and iron.

S P E C I E S IX.

Bituminous Copper Ore.

IT is said to be found in Sweden; it is a species of coal, which gives little or no flame, but from whose ashes copper is extracted.

SPECIES

SPECIES X.

Mineralized by the Vitriolic, or Marine Acids. Roman Vitriol, or native blue Vitriol.

VITRIOL of copper rarely occurs crystallized, but is often found naturally dissolved in water in Hungary, Sweden, and Ireland. 100 parts of vitriol of copper contain 27 of copper, 43 of water, and 30 of acid.

The marine salt of copper has been found in the mine of Johngeorgenstadt, in Saxony. It is of a greenish colour, of a foliated texture; moderately hard, and sometimes transparent and crystallized. It was taken for a sort of Mica; but Bergman found it to consist of copper, and the marine acid, with a little argillaceous earth.

IRON ORES.

THE basis of the calciform ores is either the black, or blackish brown calx of iron, which is in some measure phlogisticated and magnetic, or the red calx of iron, which is more dephlogisticated, and not magnetic before torrefaction.

SPECIES I.

Brown calx of Iron, mixed with Iron in its metallic State. Steel Ore.

IT is of a dark colour, solid, compact, and shining in its fracture, scarcely gives fire with steel; gives a black powder, is magnetic, and in some degree malleable when red hot. It yields from 60 to 80 of good iron, and is found at Adelfors, and Danemora, in Sweden; also in the isle of Elbe, and North America.

Crystallized iron ore in an octohædral or cubic form belongs to this species.

SPECIES II.

Magnet.

THIS differs little in its appearance from the preceding ore, but has less lustre, it is either coarse or fine grained, the coarse loses its power soonest. It seems to contain a small quantity of sulphur, as it smells of it when red hot. It is probable that it contains more particles of iron in its metallic form than the preceding ore, but it is often contaminated with a mixture of quartz and argill. It is possible it may contain nickel, for this, when purified to a certain degree, becomes magnetic. This ore has not as yet been properly examined.

SPECIES

SPECIES III.

Brown Calx of Iron, combined with Plumbago.

THIS consists of black shining scales, more or less magnetic. Rinman found it to consist of plumbago, and 26 per. cent. of iron.

SPECIES IV.

Brown Calx of Iron united with the white Calx of Manganese, and mild calcareous Earth in various Proportions. White or sparry Iron Ore.

ITS colour when fresh dug is whitish, but from exposure to air, it becomes grey, then brown, and at last reddish, yellowish, or black. Its shape is either amorphous, or rhomboidal; it is frequently transparent; its texture lamellar, scaly, granular or cellular; sometimes it assumes a stalactitical form, and sometimes it is found in a powdery state, and is then of a brown blackish colour; is frequently interspersed with quartz and pyrites, &c. and does not give fire with steel unless these foreign substances are struck. It is scarce ever magnetic before roasting, but if heated, decrepitates, grows black, becomes magnetic, and loses from 15 to 40 per cent. of its weight. 100 parts of this ore from Eifenartz, in Steria, afford, according to Bergman, 38 of the brown calx of iron, 24 of the white calx of manganese, and 38 of mild calcareous earth. Another sort from West Silvret-

berg, contains 22 of the brown calx of iron, 28 of the white calx of manganese, and 50 of mild calcareous earth.

SPECIES V.

Magnetic Sand.

THAT of Virginia is of this sort. It is of a black colour, and contains about half its weight of iron. Its composition has not yet been discovered.

SPECIES VI.

Red Calx of Iron indurated, and combined with a little Argill, and frequently with Manganese. Hematites.

IT is generally of a red, yellow, purple, or brown colour, of a metallic lustre, and very hard, though seldom so hard as to give fire with steel. When scratched it shews a red trace, it is not magnetic before roasting, but by that heat it becomes black and magnetic; its structure is either solid, granular, scaly, or fibrous; it occurs either in shapeless masses, or in a stalactitical form, or even crystallized in regular forms according to Gmelin, though Mr. Delisle denies it. In some places it forms whole mountains, and contains from 40 to 80 per cent. of iron. Gerhard found it to contain argill, and Hielm manganese. This species of iron ore, when ground into a convenient shape, and finely polished, is used for burnishing, and is called by artists burnishing stone.

SPECIES

SPECIES VII.

Hæmatites in a loose Form, mixed with a notable Proportion of Argill. Hæmatitical yellow, red, and brown Ochres.

OCHRES are distinguished from clays, by containing a large proportion of martial particles. Those that become brown by calcination, and also magnetic, belong to this species; sometimes the ferruginous particles are mixed with argill and calcareous earth, and then these ochres effervesce with acids.

SPECIES VIII.

Red Calx of Iron combined with Plumbago.

THIS differs from the black in this, that it is not magnetic before torrefaction.

SPECIES IX.

Red Calx of Iron, mixed with a small Proportion of the brown and indurated. Torsten.

THIS is of a bright, bluish black, or yellowish grey colour, and fibrous texture, shewing a red trace when scratched, and is weakly magnetic before torrefaction. According to Rinman it is less dephlogisticated than hæmatites.

SPECIES X.

Emery.

THIS seems to be a mixture of the red and white calces of iron, with some unknown stony substance. It scarcely yields in hardness to any substance except diamond; the best sort is of a dark grey colour, but becomes brown and magnetic by torrefaction; other sorts are of a reddish rusty white, or yellowish colour; it is never used as an iron ore, nor is its proportion of iron well known. It is much used in the arts for polishing; it is sold in two states, the corn emery, and the powdered emery; the latter differs from the former only in being finer pulverised, and passed through a fine sieve. The first is used for rough polishing, and the second for finishing.

SPECIES XI.

Red Calx of Iron united with the phosphoric Acid.

Grey Iron Ore.

THIS has a shining metallic appearance, and commonly gives fire with steel; it is not the least magnetic, and when scratched shews a red trace. It yields from 40 to 66 per cent. of cold short iron.

SPECIES XII.

Argillaceous Iron Ores.

OF these we may distinguish two principal varieties, viz. those found in mountains and high lands, and those found in swampy or low lands overflowed with water. Both are destitute of metallic lustre, but very weighty, and some of them when dry absorb water like clays.

VARIETY I.

High Land argillaceous Ores.

THESE are yellow, red, brown, or greyish, indurated and friable, or loose and powdery, or in grains. They consist chiefly of the red or yellow calx of iron, or of the grey iron ore, or torsten in a loose form, mixed with clay, and consequently often containing manganese or siderite; and some, particularly in France, and the neighbourhood of Liege, are said to contain the calx of zinc. Hence there is a great variety of them, and consequently their qualities must also be very different.

Horne-stone overloaded with iron, belongs to this species, and Rinman mentions an iron ore found in Kent of this species, which affords about 47 per cent. of brittle iron.

This variety never obeys the magnet before, and very rarely after torrefaction.

VARIETY

V A R I E T Y II.

Swampy argillaceous Ores.

WHEN dry this ore is friable, and brown or brownish black, and appears either in lumps, or of an irregular shape, or in round balls porous or solid; or in flat round pieces, or in grains, and sometimes in slender triangular prisms parallel to each other, and very brittle. It becomes magnetic by torrefaction, and the crude ore affords about 36 per cent. of regulus, and after calcination about 50 per cent. The iron procured from it is cold short, at least in Sweden.

Hielm has found some sorts of it to contain 28 per cent. of manganese.

S P E C I E S XIII.

Red Calcareous Iron Ore.

THIS is found in a loose form in many parts of England, and is used as a pigment.

S P E C I E S XIV.

Siliceous Iron Ore.

BESIDES jasper, garnet, and trapp, overloaded with iron, there is found, principally in France, a black, heavy, unmagnetic sand, of the siliceous kind, which is said to contain iron and zinc in great quantity.

Baron

Baron Born, in his letters from Hungary, mentions a blue crystallized iron ore, which he says is a shoerl overloaded with iron.

SPECIES XV.

Muriatic Iron Ore.

SERPENTINE, overloaded with iron, forms this species, but is seldom worked.

SPECIES XVI.

Martial Calamine.

CALAMINE is properly an ore of zinc, but sometimes it contains so large a portion of iron, as to be worked with a view of obtaining this metal. It contains quartz and clay, is of a yellow, red, or brown colour, and moderately hard.

SPECIES XVII.

Martial Pyrites.

THESE are stony concretions of sulphur, clay, and calx of iron, so hard as to give fire with steel. There are two principal varieties of them.

VARIETY I.

Pale yellow Pyrites.

SOMETIMES grey, of a globular or cubic form; it strikes fire with steel, but in the fire is very infusible. It contains from 1-6 to 1-3 of sulphur, from 1-8 to 5-8 of iron, the remainder clay and
filex;

flex; the three first intimately combined with each other, and the iron in a semi-phlogisticated state. Some pyrites instead of clay, contain calcareous earth, these are common in France, and the iron in them is in a dephlogisticated state.

VARIETY II.

Brown, or reddish brown Pyrites.

IT is generally of a spherical shape, or crystallized in cubic, rhomboidal, or other forms, and is devoid of metallic lustre; it difficultly gives fire with steel, and contains very little sulphur, but much more iron than the yellow pyrites. It is sometimes magnetic before, but always after torrefaction. It sometimes contains calcareous earth. The iron it affords is very brittle.

SPECIES XVIII.

Mineralized with Sulphur and Arsenic, white, grey, or bluish grey Pyrites, or Marcassite.

IT is found either in solid compact masses of a moderate size, or in grains, it gives fire with steel; when burnt, it gives a blue flame, and an arsenical smell, and by distillation, orpiment, or realgar; it is not magnetic either before or after torrefaction. It contains more arsenic than sulphur.

SPECIES

SPECIES XIX.

Mineralized by Arsenic. Mispickite.

IT is of a bright white, resembling a mixture of silver and tin, and unalterable by exposure to air. Its form either granular, prismatic, rhomboidal, &c. It is neither magnetic before nor after torrefaction; it affords arsenic by distillation in the proportion of 30 or 40 per cent. and sometimes contains a little copper and silver; it is frequently mixed with other metallic ores, and often found in indurated clay, quartz, spar, &c. Whenever iron contains less than 1-16 of arsenic, it is magnetic.

SPECIES XX.

Combustible Iron Ore.

CRONSTED mentions two varieties of this kind; one of which the greater part is volatile, in a strong heat long continued, and seems to contain iron, plumbago, and coal intimately mixed. The other burns with a languid flame, loses about 1-5 of its weight, resembles pit coal, but is somewhat harder, and yields about 30 per cent. of iron.

SPECIES XXI.

Native green Vitriol, Copperas. Mineralized by the vitriolic Acid.

IT is frequently found native in coal-mines, in cavities of pyritaceous mines, or in shistus; it is
also

also found in small round stones, called ink-stone, of a white, red, grey, yellow, or black colour; soluble in water, and containing a portion of copper and zinc.

UNCERTAIN MINERALIZATIONS.

SPECIES XXII.

Iron Blende.

THIS is a stone of a grey iron colour, formed of diverging laminæ, of great hardness, and a metallic appearance, and infusible in the strongest fire. Sometimes it contains arsenic, in this case, it blackens by exposure to the air.

SPECIES XXIII.

Wolfram.

THIS stone, which is generally found in tin mines, is of a black or brown shining colour, of a radiated or foliated texture, of a moderate hardness, and sometimes so brittle, as to be easily broken between the fingers; when scratched it shews a red trace, which distinguishes it from tungsten. According to Lehman, it consists of siliceous earth, calx of iron, and a small portion of calx of tin. The nature of this substance is still somewhat obscure, but upon the whole it appears to be an ore of manganese, mineralised by the tungstenic acid; for, from a skilful
analysis

analysis of Mess. de Luyart, the following constituent parts were obtained.

Yellow earth of tungsten	65	parts
Manganese - - - -	22	
Calx of iron - - - -	13½	
Quartz and tin - - - -	2	

SPECIES XXIV.

Native Prussian Blue.

IT consists of clay, mixed with iron and some unknown tinged substance; generally found in bogs or swampy grounds; it is at first white, but on exposure to air becomes blue; by heat it turns green, emits a slight flame, and becomes magnetic. The earth of Beuthnitz, in Silesia, mentioned in the memoirs of Berlin for 1757, belongs to this species, and contains about 1-4 of its weight of iron.

SPECIES XXV.

Green Earth of Verona, in Normandy. Terre Verte.

IT is used as a pigment, and contains iron in some unknown state, mixed with clay, and sometimes chalk and pyrites. It is said to afford about 40 per cent. of iron; alum and selenite are sometimes accidentally found with it. It is not magnetic before torrefaction, and becomes of a coffee-colour when heated.

T I N O R E S.

S P E C I E S I.

Calci form Ores.

THESE ores are remarkable for their great weight, they are reduced to four varieties.

V A R I E T Y I.

Tin Spar, or white Tin Ore.

IT is generally of a white or grey colour, sometimes greenish or yellowish, semi-transparent, or crystallized in a pyramidical form, or irregularly. It was formerly thought to contain arsenic, but Margraaf found it the purest of all tin ores. It sometimes contains a mixture of calcareous earth.

V A R I E T Y II.

Opake, brown, or black Tin Ore.

THIS is also crystallized and imbedded in a stony matrix of quartz, fluor or mica, or mixed with white or yellow pyrites; or in ores of lead, zinc, cobalt, bismuth, or iron. The black are reckoned the richest, and afford about 80 per cent. of tin; they all contain a mixture of iron.

When any arsenic is found in tin, it proceeds from the matrix, for tin itself is never mineralized by it; and for the same reason zinc is sometimes found in tin.

VARIETY

V A R I E T Y III.

Reddish, or reddish yellow Tin Ore, garnet Tin Ore.

THIS consists of small crystals, semi-transparent or opaque; sometimes it is found of a spherical form, striated, and resembling Hæmatites. It contains more of iron than of tin.

V A R I E T Y IV.

Tin Stone.

THE preceding varieties consist for the most part of metallic particles, the present chiefly of stones, or sands of different sorts; which contain calx of tin invisibly diffused through them. They may be of any colour; blue, grey, black, and brown, are the commonest; they are called lodestones.

It is remarkable that tin has not as yet been found in any stones of the calcareous genus, except fluors; but only in those of the siliceous or argillaceous kind.

S P E C I E S II.

Mineralized by Sulphur.

THIS was lately discovered by Bergman among some minerals, which he received from Siberia. He observed two species of it analogous to two artificial combinations of tin with sulphur; the one nearly of the colour of zinc, of a fibrous texture,

D 2

which

which contained about 20 per cent. of sulphur, and the remainder tin. The other enveloped the former like a crust, resembled aurum musivum, and contained about 40 per cent. of sulphur, a small portion of copper, and the remainder tin.

Tin ores are very scarce, not being hitherto found in any considerable quantity, except in the East Indies, Cornwall, Bohemia, and Saxony.

L E A D O R E S.

Calci form Ores.

OF those, five varieties are ascertained, all contain a little iron, but never silver.

V A R I E T Y I.

White Lead Spar, Lead Ochre, native Ceruss.

IT is sometimes transparent, but generally opaque and crystallized in regular forms, of a laminar or striated texture. Lead ochre, or native ceruss, is the same substance, but in a loose form, or indurated and shapeless; sometimes it is found in a silky form; both contain a little iron, and sometimes calcareous earth and argill. They afford from 60 to 80 or 90 per cent. of lead, and are found in Brittany, Lorraine, Germany, and England.

VARIETY

VARIETY II.

Red, brown, or yellow.

THIS is also found either regularly crystallized, or in shapeless masses, or in powder; it differs from the above only by containing more iron. That in powder, contains a mixture of clay, and affords about 60 or 80 per cent. of lead.

VARIETY III.

Green.

EITHER crystallized in needles, as in Brittany; or in a loose powder, as in Saxony; but mostly adhering to, or investing quartz. It owes its colour to iron, and seldom contains copper.

VARIETY IV.

Bluish.

THIS is sometimes crystallized, and sometimes not. It owes its colour to a mixture of copper.

VARIETY V.

Black.

THIS is the most uncommon of all, and occurs either crystallized, or of an indeterminate form.

SPECIES II.

Mineralized by the vitriolic Acid.

THIS sometimes occurs in the form of a white ponderous calx, soluble in 16 or 18 times its weight

D 3.

in

in water. It originates from the spontaneous decomposition of fulphurated lead ores.

SPECIES III.

Mineralized by the Phosphoric Acid.

THIS species was first discovered by Mr. Gahn; it is of a greenish colour, by reason of a mixture of iron.

SPECIES IV.

*Mineralized by Sulphur, with Silver and a little Iron.
Galena, Potters Ore.*

IT is the commonest of all lead ores, of a bluish dark red colour, formed of cubes of a moderate size, or in grains of a cubic figure, whose corners have been cut off; its texture is lamellar, and its hardness variable. The hardest sort containing a great mixture of iron or quartz, that in grains is thought to be the richest in silver; but the richest contains only about 1 or 1-5 per cent. that is 12 or 18 ounces per quintal, the poorest about 60 grains. Ores which yield about half an ounce per quintal of silver, are barely worth the cost of extracting it. The proportion of sulphur to lead in this ore is variable, within the limits of 15 and 25 per cent. The proportion of lead is from 60 to 85 per cent. that of iron is very small.

It is remarked, that the ores which are poorest in lead, are often the richest in silver.

SPECIES

SPECIES V.

Mineralized by Sulphur, with Silver and Regulus of Antimony. Antimonial Lead Ore.

ITS appearance is like galena, but its texture is different, being radiated, filamentous, or striated; when heated it affords a white smoke. It yields from 40 to 50 per cent. of lead, and from half an ounce to two ounces of silver per quintal.

SPECIES VI.

Mineralized by Sulphur, with Silver, and a large Portion of Iron. Pyritous Lead Ore.

THIS is of a brown or yellowish colour, of an oblong or stalactitical form, friable, and of a lamellar, striated, or loose texture; it affords at most 18 or 20 per cent. of lead, which flows by barely heating it, as the iron detains the sulphur. It is no more than a mixture of galena, with the brown pyrites.

SPECIES VII.

Mineralized by Sulphur and Arsenic, with Silver. Red Lead Spar

DISCOVERED first in Siberia; externally it is of a pale, and internally of a deep red, and for the most part crystallized in rhomboidal, or irregular pyramids. It contains, according to Lehman, sulphur, arsenic, and about 34 per cent. of lead; and according to Pallas also silver.

SPECIES VIII.

Stony or Sandy Lead Ore.

THIS consists either of the calciform lead ores, or galena, intimately mixed and diffused through stones or earths, chiefly of the calcareous kind.

Ores of lead are most frequently found among stones of the calcareous or barytic genus.

ORES OF MERCURY.

SPECIES I.

Mineralized by the aerial Acid. Native precipitate per se, or Calx of Mercury.

THIS is said to have been found in Idria, in hard compact masses, of a brownish red colour, and granular texture, mixed with some globules of native mercury. 100 parts afford about 91 of running mercury.

SPECIES II.

Mineralized by the vitriolic and marine Acids. Vitriolic and marine Salt of Mercury.

Mr. Woulfe first discovered these salts at Obermoschel, in the Duchy of Deuxponts, they have a spar-like appearance, and are either bright and white, or yellow, or black, mixed with cinnabar, in a

stony matrix. These well mixed afforded him, with 1-3 of their weight of vegetable alkali, cubic and octagonal crystals, that is, salt of sylvius, and tartar vitriol. The marine salt of mercury is in the state of corrosive sublimate.

S P E C I E S III.

Mineralized by Sulphur. Native Cinnabar, Vermillion.

IT is of different shades, from a yellow to a deep red, and is found either pure, in hard friable masses; either shapeless, or crystallized in cubes, and sometimes transparent, or intermixed with clay or stone, or interspersed through the ores of other metals, particularly those of silver, copper, or martial pyrites; its texture is either radiated, striated, scaly, or granular. 100 parts of cinnabar contain about 80 of mercury, and 20 of sulphur. Artificial cinnabar contains rather more sulphur, and hence its colour is darker.

S P E C I E S IV.

Mineralized by Sulphur with Copper. Black Ore of Mercury.

ACCORDING to Cronsted and Linneus, this ore is of a blackish grey colour, glassy texture, and decrepitates strongly when heated; the cinnabar is volatilized, and the copper remains, and may be distinguished by the usual tests.

SPECIES

SPECIES V.

Pyritous Mercurial Ore.

MONNET relates that he found in Dauphiné, a grey or whitish friable substance, 100 parts of which afforded one of mercury, half of silver, and the remainder iron, cobalt, sulphur, and arsenic.

Cinnabar mixed with arsenic, or realgar, is said to be found in Japan.

At Morsfield, cinnabar and the white calx of arsenic, present themselves in the same rock.

ORES OF ZINC.

ALL the ores of Zinc tinge plates of copper when stratified with them and charcoal; only the sulphureous require previous torrefaction.

SPECIES I.

Mineralized by the aerial Acid. Calciform Ores.

OF these, there are four varieties.

VARIETY I.

Pure Calx of Zinc. Zinc Spar.

OF a whitish grey, bluish grey, or yellowish colour, and of a hardness generally sufficient to strike fire with steel; in its fracture it resembles quartz, stalaclitical,

stalaçtitical, or crystallized in groups, and weighty; by torrefaction it loses 1-3 of its weight, without emitting a sulphureous or arsenical smell, and is infusible in the strongest heat singly, or with mineral alkali, but easily fusible with borax: 100 grains of this ore contains about 65 of the calx of zinc, 28 of aerial acid, 6 of water, and 1 of iron, and sometimes a little silex.

VARIETY II.

With a notable Proportion of Iron. Tutenago.

Mr. ENGESTROM, in the memoirs of Stockholm, for the year 1775, has given us an analysis of an ore of this sort from China, it was of a white colour, interspersed with red streaks of calx of iron, and so brittle as to be easily broken between the fingers. It contains in various specimens from 60 to 90 per cent. of zinc, the remainder was iron, and a small portion of clay. Bindheim discovered this variety in Germany, and found it to consist of zinc, a little iron, and silex.

VARIETY III.

Mixed with Iron and Clay in various Proportions.

Calamine.

ITS colour is white, grey, yellow, brown, or red, not so brittle as the second variety, and of various degrees of hardness, though scarce ever so hard as to strike fire with steel; its texture equable or cellular,
and

and its form either amorphous, crystallized, or stactitital, when calcined it loses no part of its weight, unless it be mixed with charcoal, and then flowers of zinc sublime. The best sort affords from 100 parts, 84 of calx of zinc, 3 of iron, 1 of clay, and 12 of filex. But in other specimens these proportions, are very different, some ores are so poor as not to contain above 4 per cent. of calx of zinc; a good ore should afford at least 30 per cent. Sometimes calamines contain a mixture of calcareous earth and lead. Most of the English contain lead.

V A R I E T Y IV.

Mixed with a notable Proportion of Silex. Zeolytiform.

THE real contents of this substance, were first discovered by Mr. Pelletier, of Paris. It was long taken for a zeolyte, being of a pearl colour, crystallized, semi-transparent, consisting of laminæ, diverging from different centres, and becoming gelatinous with acids. It was commonly called zeolyte of Friburgh; he found 100 grains to contain from 48 to 52 of quartz, 36 of calx of zinc, and 8 or 12 of water.

S P E C I E S II.

Mineralized by the vitriolic Acid. Native white Vitriol.

IT is sometimes found native, mixed with vitriol of iron, and in the form of white hairy crystals, or in a sta-

a stalactitical form, in the galleries of mines, in Hungary, Goslaar, &c. or as an efflorescence on ores of zinc; it is also found dissolved in mineral waters, and generally with some portions of vitriol of iron and copper. 100 parts of vitriol of zinc, contain 22 of acid, 20 of zinc, and 58 of water.

SPECIES III.

Mineralized by Sulphur by means of Iron. Blende, Black-jack.

OF this there are several varieties, almost all contain a mixture of lead-ore, most of them exhale a sulphureous smell, when scraped, or at least when vitriolic or marine acid is dropped upon them.

VARIETY I.

Bluish grey, and of a metallic Appearance.

ITS form is generally cubical or rhomboidal, its texture scaly or steel-grained; by torrefaction it loses 1-6 of its weight. 100 parts afforded about 52 of zinc, 8 of iron, 4 of copper, 26 of sulphur, 4 of water, and 6 of filix.

VARIETY II.

Black-pecheblende.

OF moderate hardness, does not give fire with steel, frequently crystallized, and then sometimes transparent; when pulverised it gives a reddish powder, when
heated

heated it decrepitates, and if laid on a burning coal it emits a sulphureous smell, and depofes white and yellow flowers; it is not magnetic even after torrefaction, after which it lofes 25 per cent. of its weight. It is frequently mixed with silver, arfenic, and other metals. 100 parts of that of Danemora yielded 45 of zinc, 1 of regulus of arfenic, 9 of iron, 6 of lead, 29 of fulphur, 6 of water, and 4 of filex.

V A R I E T Y III.

Red, or reddish-brown.

ITS texture is fcaly, fometimes cryftallized, and femi-transparent, it gives fire with fteel; it does not decrepitate nor fmoke when heated, and lofes about 13 per cent. by torrefaction. 100 parts of that of Sahlberg, yielded 44 of zinc, 5 of iron, 17 of fulphur, 5 of water, 5 of clay, and 24 of quartz.

V A R I E T Y IV.

Phofphorefcant Blende.

ITS colour is generally greenifh, yellowifh green, or red, of different degrees of transparency or opake, when fcraped with a knife in the dark, it emits light even in water, and after undergoing a white heat, when diftilled per fe, a filiceous fublimatc rifcs, which fhews it contains the fparry acid. 100 parts of that of Scharfenberg, contain 64 of zinc, 5 of iron, 20 of fulphur, 4 of fluor acid, 6 of water, and 1 of filex.

VARIETY

VARIETY V.

Greyish yellow Blende.

THIS consists of a mixture of blende, galena, and petrol; it contains about 24 per cent. of zinc.

VARIETY VI.

White Blende.

Found at Silverberget.

VARIETY VII.

Yellow Blende.

OF the colour of wax, and semi-transparent, containing much sulphur.

ORES OF ANTIMONY.

SPECIES I.

Mineralized by the aerial Acid. Native Calx of Antimony.

IT consists of a group of white crystallized filaments, diverging from a common center; urged with a blow-pipe on charcoal it will dissipate, which together with its insolubility in nitrous acid is sufficient to distinguish it.

SPECIES

SPECIES II.

Mineralized by Sulphur. Antimony.

IT is dark or bluish grey, its texture is fibrous, solid, or lamellar, this last is sometimes called antimonial galena; its form generally indeterminate, but sometimes crystallized, it is the most fusible of all ores. 100 parts contain 74 of regulus, and 26 of sulphur.

SPECIES III.

Mineralized by Sulphur and Arsenic. Arsenicated Antimony.

THIS is the same as the plumose silver ore, besides the colours there mentioned, it is found red or green, and then contains but a small portion of silver. Its texture, filamentous, very brittle, and fusible.

ORES OF ARSENIC.

SPECIES I.

Mineralized by the aerial Acid. Native Calx of Arsenic.

IT is found either indurated in white, opaque, transparent, or semi-transparent crystals; or in a loose

loose powdery state, frequently mixed with native arsenic; it is volatile when heated, but does not detonate with nitre, though an effervescence arises.

S P E C I E S II.

Mineralized by Sulphur.

Of these there are two varieties, the yellow and the red; both sublimable in close vessels, and detonate with nitre. With fixed alkalies they both form a hepar.

V A R I E T Y I.

Yellow Orpiment.

THIS is rarely found crystallized; it is generally composed of shining flexible laminæ like mica, more or less solid. It contains about 1-10 of its weight of sulphur, and burns with a blue flame.

V A R I E T Y II.

Red Realgar.

IT is found either in shapeless or stalactitical masses, opaque or semi-transparent, and regularly crystallized in octohædral pyramids or prisms, and then called ruby of Arsenic. 100 parts contain 16 of sulphur.

SPECIES III.

Calx of Arsenic diffused through Earths or Stones.

HENCKEL mentions a grey or bluish marl in which this calx was found. Clay and calcareous earth are sometimes impregnated with it; it is discovered either by the smell when laid on burning coals, or by lixiviation.



ORES OF BISMUTH.

SPECIES I.

Mineralized by the aerial Acid. Native Calx of Bismuth.

WHEN pure it is of a yellowish white colour, and either in a powdery form, or indurated like mortar; but it is frequently of a greenish yellow colour, being mixed with ores of other metals; the red and yellow part is most commonly cobalt ore, though it is often mistaken for bismuth. It is frequently found in glittering particles interspersed through stones of various kinds, silver, iron, and other metals are also found in it.

SPECIES II.

Mineralized by vitriolic Acid.

THIS is said to be of a yellowish, reddish, or variegated colour, and to be found mixed with the calx of bismuth, incrusting other ores.

SPECIES III.

Mineralized by Sulphur.

IT is chiefly found in Sweden, of a bluish grey colour, lamellar texture, like galena, but much heavier; it is said to contain besides bismuth, cobalt and arsenic. This ore is very fusible, and the sulphur mostly separates on scorification.

SPECIES IV.

Mineralized by Sulphur and Iron.

THIS is said to be of a lamellar cuneiform texture, and to be found in Norway.

ORES OF COBALT.

SPECIES I.

Mineralized by aerial Acid. Black Ochre of Cobalt.

THIS appears either in a loose powdery form, sometimes as fine as lamp-black, or grey, or blackish,

or in black indurated masses, when it is called vitreous cobaltic ore; it is commonly free from sulphur and arsenic; when there are any, they are only mechanically mixed; sometimes small portions of copper and iron are also found in it. It is found imbedded in stones, sands, &c.

S P E C I E S II.

Mineralized by the vitriolic or arsenical Acids. Red Cobalt Ochre.

THIS also is found either loose or pure, or mixed with chalk or gypsum, or indurated and crystallized in tetrahædral crystals, or in a stalactitical form; it melts easily, and then becomes blue; it frequently invests other cobaltic ores, and is found sometimes in stones or sand.

Bergman has shewn that the arsenical acid, and not the calx of arsenic enters into this combination, for cobalt is never red, but when united to an acid.

S P E C I E S III.

Mineralized by Arsenic with scarce any Iron. Grey Cobalt Ore.

Solid, heavy, compact, sometimes of a dull, and sometimes of a bright appearance, frequently crystallized, and generally so hard as to give fire with steel.

SPECIES IV.

Mineralized by Arsenic and Sulphur with Iron. White arsenicated Cobalt Ore.

THIS bears a great resemblance to the preceding, but is softer, and never strikes fire with steel. It sometimes may be easily scraped with a knife, and mostly appears crystallized under some polygon form.

SPECIES V.

Mineralized by a small Portion of Sulphur, with a notable Portion of Iron, without any Arsenic. White unarsenicated Cobalt Ore.

IT is sometimes found in large masses, and sometimes in grains crystallized, of a dull white colour, and frequently bears the appearance of a mispickles; it becomes black, and not red by torrefaction, which distinguishes it from pyrites. No sulphur can be extracted from it, and it contains much more iron than it does cobalt.

ORES OF NICKEL.

SPECIES I.

Mineralized by aerial Acid. Native Calx of Nickel.

IT is found in the form of a green calx, mixed with calx of iron, scattered over the ore of kupfer-nickel, and also in some green clays.

SPECIES II.

Mineralized by the vitriolic Acid. Vitriol of Nickel.

THIS is with difficulty soluble in water, its solution is green, it is found native, but generally mixed with vitriol of iron.

SPECIES III.

Mineralized by Sulphur and Arsenic, with Cobalt and Iron. Kupfernickel.

IT is of a reddish yellow bright colour, its texture either uniform, granular, or scaly, bright in its fracture, very heavy, and generally covered with a greenish efflorescence. By torrefaction it loses much of its sulphur, becomes green, and forms fungous ramifications.

ORES OF MANGANESE.

SPECIES I.

Mineralized by the aerial Acid. Native Calces of Manganese.

THE aerial acid is the only mineralizer of manganese in a dry state yet known, and according to the different degrees of phlogistication of the manganese; it forms with it calces of different colours. The principal of which are blue, green, yellow, red,

red, brown, or black. Blue is that which it acquires from the proportion of phlogiston, which it is enabled to retain by reason of its union with fixed alkalies: green arises from a mixture of the blue with the yellow calx of iron, yellow from the prevalence of the calx of iron, red from a slight phlogistication of the calx of manganese, and black from its perfect dephlogistication. When manganese is in the highest state of phlogistication, without being in a reguline state, it is of a white colour. All these calces whatever colour they may be, communicate a garnet colour to glass of borax, when treated with the blow-pipe.

There are three varieties, principally distinguished of the native calx of manganese.

VARIETY I.

White Ore of Manganese.

IT contains but a small portion of iron. Rinman found it in small white crystals, and in round masses in the cavities of quartz, &c. of a sparry texture, and scarcely magnetic even after roasting.

VARIETY II.

IT contains less fixed air and more iron than the former variety; it is found either loose, or semi-indurated in a matrix of calcareous spar, talky shistus, iron ores, &c. or in heavy hard masses crystallized variously.

V A R I E T Y III.

Black and brown Ores of Manganese.

THESE differ little from each other, they are found either crystallized in the same form as the red ore, or in solid masses, some of which have a metallic appearance, others are dull, earthy, or mixed, or embodied with quartz, or in a loose earthy form. They contain more iron and less fixed air than the former varieties.

S P E C I E S II.

Black-Wad.

IT is of a dark brown colour, partly in powder, and partly indurated, and brittle. 100 parts of it contain 43 of manganese, 43 of iron, 4 of lead, and 5 of Mica.

It is remarkable that if this species be well dried before a fire, and afterwards suffered to cool; and then, by adding two ounces of linseed oil gradually, and mixing them loosely, in about half an hour it begins to grow hot, and at last bursts into a flame.

M O L Y B D E N A.

IT resembles plumbago, or black lead, but its laminæ are larger, brighter, and when thin, slightly flexible; it is of a lead colour, and does not strike fire with steel.

Mr.

Mr. Scheele found it to consist of an acid of a peculiar nature united to sulphur; a small portion of iron is commonly found in it, but it seems merely fortuitous. 100 parts contain 45 of acid, and 55 of sulphur.

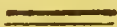
It is decomposed by detonation with nitre, or by solution in nitrous acid; this latter method is the readiest. For this purpose it is to be five times distilled, each time with four times its weight of spirit of nitre; a white calx at last remains, which is the molybdenous acid.

Mr. Hielm has reduced this acid. He calcined the molybdena and put it into a crucible, with a mixture of fat and charcoal dust, and covered it with a copper cover. The crucible was exposed to the intense heat of a forge for half an hour, a part of the molybdena was fused and found at the bottom of the crucible in small brilliant globules; and the rest was united to the copper cover and melted.

TUNGSTEN.

AS this acid is of a metallic nature, a few of its distinguishing properties may properly be inserted here. First, Its solution in water reddens litmus, with alkalis it forms crystallizable salts; with calca-
reous

reous earth, barytes, and magnesia, insoluble compounds. Secondly, this solution is precipitated white by the Prussian alkali, and the precipitate is soluble in water. Thirdly, it precipitates the solutions of vitriols of iron, zinc, copper, and the nitrous solutions of silver, mercury, and lead, and that of lead in marine acid. The solution of tin in marine acid, is precipitated blue, but the solutions of gold and corrosive sublimate, are not altered by it; and fourthly, the solutions of chalk or alum are not altered by it, but that of barytes in acetic acid, is precipitated, and the precipitate is insoluble.



ON THE ASSAYING OF METALLIC ORES.

BEFORE metallic ores are worked upon in a large way, it will be necessary to enquire what sort of metal, and what portion of it, is to be found in a determinate quantity of the ore; to discover whether it will be worth while to extract it in the great, and in what manner the process should be conducted so as to answer that purpose. The knowledge requisite for this is called the art of assaying, which is the same thing in little, as the process of smelting is in the great.

The

The assaying of ores may be performed either in the dry or moist way; the first is the most ancient, and in many respects the most advantageous, and consequently still continues to be mostly used.

Assays are made either in crucibles with the blast of the bellows, or in tests under a muffle.

The assay-weights are always imaginary, sometimes an ounce represents an hundred weight on the large scale, and is sub-divided into the same number of parts, as that hundred weight is in the great; so that the contents of the ore obtained by the assay, shall accurately determine by such relative proportion, the quantity to be expected from any weight of ore on a larger scale.

In the lotting of the ores, care should be taken to have small portions from different specimens, which should be pulverized, and well mixed in an iron or brass mortar. The proper quantity of the ore is now taken, and if it contain either sulphur or arsenic; it is put into a crucible or test, and exposed to a moderate degree of heat, till no vapour arises from it; and to assist this volatilization, some add a small quantity of powdered charcoal, this process is called the roasting of the ore.

To assist the fusion of the ores, and to convert the extraneous matters connected with them into Scoria; assayers use different kinds of fluxes. The most usual and efficacious materials for the composition

sition of which, are, borax, tartar, nitre, sal ammoniac, common salt, glass, fluor spar, charcoal powder, pitch, lime, litharge, &c. different proportions of which united together form fluxes.

Some of the principal fluxes, are composed as follows:

CRUDE, OR WHITE FLUX.

ONE part of nitre, and two of tartar, well mixed together.

BLACK FLUX.

THE above crude flux detonates by means of kindled charcoal, if the detonation be effected in a mortar slightly covered, the smoke that rises unites with the alkalisied nitre and the tartar, and renders it black in consequence of a slight degree of phlogification.

CORNISH REDUCING FLUX.

TEN ounces of tartar ; 3 ounces and 6 drachms of nitre, and 3 ounces and 1 drachm of borax ; mix them well together.

CORNISH REFINING FLUX.

TWO parts of nitre, and 1 part of tartar, defflagrate them, and afterwards pulverize.

These

These fluxes answer the purpose very well, providing the ores be deprived of all their sulphur; or, if they contain much earthy matters, because in the latter case, they unite easily with them, and convert them into a thin glass, but if any quantity of sulphur remain, these fluxes unite with it, and form a liver of sulphur, which has the power of destroying a portion of all the metals; consequently the assay under such circumstances must be very inaccurate. The principal difficulty in assaying, appears to be in the appropriation of the proper fluxes to each particular ore, and it likewise appears, that such a discriminating knowledge can only be acquired from an extensive practice, or from a knowledge of the chemical affinities and actions of different bodies upon each other.

ORES *and* EARTHS *containing* GOLD *may be assayed by the following* METHODS.

I. THAT which is now most generally used is by amalgamation, the proper quantity is taken and reduced to a powder; about 1-10 of its weight of pure quicksilver is added, and the whole triturated in an iron mortar. The attraction subsisting between the gold and quicksilver, quickly unites them in the form of an amalgam, which is pressed through shamoy

shamoy leather; the gold is easily separated from this amalgam, by exposure to a proper degree of heat, which evaporates the quicksilver, and leaves the gold. This evaporation should be made with luted vessels.

This is the foundation of all the operations by which gold is obtained from the rich mines of Peru, in Spanish America.

II. Take a quantity of the gold sand and heat it red-hot, quench it in water; repeat this two or three times, and the colour of the sand will become of a reddish brown. Then mix it with twice its weight of litharge, and revive the litharge into lead, by adding a small portion of charcoal dust, and exposing it to a proper degree of heat; when the lead revives, it separates the gold from the sand; and the freeing of the gold from the lead must be afterwards performed by cupellation; or,

III. Bergman assays metallic ores containing gold, by mixing two parts of the ore well pounded and washed, with one and a half of litharge, and three of glass; covering the whole with common salt, and melting it in a smith's forge, in a covered crucible; he then opens the crucible, puts a nail into it, and continues to do so till the iron is no longer attacked. The lead is thus precipitated which contains the gold, and is afterwards separated by cupellation.

To

To make an ASSAY of SILVER ORES.

I. Take the assay quantity of the ore finely powdered, and roast it well in a proper degree of heat, frequently stirring it with an iron rod; then add to it about double the quantity of granulated lead, put it in a covered crucible, and place it in a furnace, raise your fire gently at first, and continue to encrease it gradually till the metal begins to work; if it should appear too thick, make it thinner by the addition of a little more lead; if the metal should boil too rapidly the fire should be diminished. The surface will be covered by degrees with a mass of scoria, at which time the metal should be carefully stirred with an iron hook heated, especially towards the border, lest any of the ore should remain undissolved; and if what is adherent to the hook when you raise it from the crucible, melts quickly again, and the extremity of the hook after it is grown cold, is covered with a thin, shining, smooth crust, the scorification is perfect; but on the contrary, if while you are stirring it, you perceive any considerable clamminess in the scoria, and when it adheres to the hook, though red hot, and appears unequally tinged, and seems dusty or rough with grains interspersed here and there, the scorification is incomplete; in consequence of which the fire should be encreased a little, and what adheres to the hook should be gently beaten off, and returned

returned with a small ladle into the crucible again. When the scorification is perfect, the metal should be poured into a cone, previously rubbed with a little tallow, and when it becomes cold the scoria may be separated by a few strokes of a hammer. The button is the produce of the assay. Or,

II. By cupellation. Take the assay quantity of ore, roast and grind it with an equal portion of litharge, divide it into two or three parts, and wrap each up in a small bit of paper; put a cupel previously seasoned under a muffle, with about six times the quantity of lead upon it. When the lead begins to work, carefully put one of the papers upon it, and after this is absorbed, put on a second, and so on till the whole quantity be introduced; then raise the fire, and as the scoria is formed, it will be taken up by the cupel, and at last the silver will remain alone. This will be the produce of the assay, unless the lead contains a small portion of silver, which may be discovered by putting an equal quantity of the same lead on another cupel, and working it off at the same time; if any silver be produced it must be deducted from the assay. This is called the witness.

To make an ASSAY of COPPER-ORES.

TAKE an exact troy-ounce of the ore previously pulverised, and calcine it well, stir it all the time with an iron rod, without removing it from the crucible; after the calcination add an equal quantity of borax, half the quantity of fusible glass, 1-4 the quantity of pitch, and a little charcoal dust; rub the inner surface of the crucible with a paste composed of charcoal dust, a little fine powdered clay, and water. Cover the mass with common salt, and put a lid upon the crucible which is to be placed in a furnace; the fire is to be raised gradually till it burns briskly, and the crucible continued in it for half an hour, stirring the metal frequently with an iron rod, and when the scoria which adheres to the rod appears clear, then the crucible must be taken out and suffered to cool; after which it must be broken, and the regulus separated and weighed; this is called black copper, to refine which equal parts of common salt and nitre are to be well mixed together. The black copper is brought into fusion, and a tea spoonful of the flux is thrown upon it, which is repeated three or four times, when the metal is poured into an ingot mould, and the button is found to be fine copper.

To make an ASSAY of IRON ORES.

THE ore must be roasted till the vapour ceases to arise. Take two assay quintals of it, and triturate them with one of fluor spar, 3-4 of a quintal of powdered charcoal, and 4 quintals of decrepitated sea salt; this mixture is to be put into a crucible, lined on the inside with clay and powdered charcoal, a cover must be luted upon the crucible, and the crucible itself exposed to a violent fire for an hour, and when it is cool, broken. When, if the operation has been well conducted, the iron will be found at the bottom of the crucible; to which must be added those metallic particles, which may adhere to the scoria. The metallic particles so adhering may be separated, by pulverising it in paper, afterwards attracting them with a magnet.

If the ore should be in a calciform state mixed with earths, the roasting of it previous to assaying, if not detrimental, is at least superfluous; if the earths should be of the argillaceous and siliceous kind, to half a quintal of them, add of dry quick lime and fluor spar of each 1 quintal and 1-4 reduced to powder, and mix them with 1-4 of a quintal of powdered charcoal, covering the whole with 1 ounce of decrepitated common salt, and expose the luted crucible to a strong forge-fire for an hour and a quarter,

quarter, then let it gradually cool, and the regulus must be struck off and weighed.

If the ore contain calcareous earth, there will be no occasion to add quick lime; the proportion of the ingredients may be as follows: viz, 1 assay quintal of the ore, 1 of decrepitated sea-salt, 1-2 of powdered charcoal, and 1 of fluor spar, and the process conducted as above.

There is a great difference in the reguli of iron, when the cold regulus is struck with a hammer and breaks, the iron is called cold short; if it break on being struck red-hot, it is called red short; but if it resist the hammer both in its cold and ignited state, it is good iron.

TO ASSAY TIN ORES.

MIX a quintal of tin-ore, previously washed, pulverised, and roasted till no arsenical vapour arises, with half a quintal of calcined borax, and the same quantity of pulverised pitch; these are to be put into a crucible moistened with charcoal dust and water, and the crucible placed in an air-furnace. After the pitch is burnt, give a violent fire for a quarter of an hour, and then withdraw the crucible, the regulus will be at the bottom. If the ore be not well washed from earthy matters, a larger quantity of borax will

F 2

be

be requisite, with some powdered glass; and if the ore contain iron, some alkaline salt may be added.

TO ASSAY LEAD ORES.

AS most of the lead ores contain either sulphur or arsenic, they require to be well roasted. Take a quintal of roasted ore, with the same quantity of calcined borax, half a quintal of fine powdered glass, a quarter of a quintal of pitch, and as much clean iron filings. Line the crucible with wetted charcoal dust, and put the mixture into the crucible, and place it before the bellows of a forge-fire, and when it is red hot, raise the fire for 15 or 20 minutes, then withdraw the crucible, and break it when cold.

TO ASSAY MERCURIAL ORES.

THE calciform ores of mercury, are easily reduced without any addition. A quintal of the ore is put into a retort, and a receiver luted on, containing some water; the retort is placed in a sand bath, and a sufficient degree of heat given it, to force over the mercury which is condensed in the water of the receiver.

The sulphureous ores are assayed by distillation in the manner above, only these ores require an equal weight

weight of clean iron filings to be mixed with them, to disengage the sulphur, while the heat volatilizes the mercury, and forces it into the receiver. These ores should likewise be tried for cinnabar, to know whether it will answer the purpose of extracting it from them; for which a determinate quantity of the ore is finely powdered and put into a glass vessel, which is exposed to a gentle heat at first, and gradually increased till nothing more is sublimed. By the quantity thus acquired, a judgment may be formed whether the process will answer. Sometimes this cinnabar is not of so lively a colour as that which is used in trade; in this case, it may be refined by a second sublimation; and if it be still of too dark a colour, it may be brightened by the addition of a quantity of mercury, and subliming it again.

To ASSAY ORES of ZINC.

TAKE your assay weight of roasted ore, and mix it well with 1-8 part of charcoal dust, put it into a strong luted earthen retort, to which must be fitted a receiver; place the retort in a furnace, and raise the fire, and continue it in a violent heat for two hours, suffer it then to cool gradually, and the zinc will be found adhering to the neck of the retort in its metallic form.

To ASSAY ORES of ANTIMONY.

TAKE a common crucible, and bore a number of small holes in the bottom, and place it in another crucible a size smaller, luting them well together; then put the proper quantity of ore in small lumps into the upper crucible, and lute thereon a cover; place these vessels on a hearth, and surround them with stones about six inches distant from them; the intermediate space must be filled with ashes, so that the undermost crucible may be covered with them; but upon the upper, charcoal must be laid, and the whole made red hot by the assistance of hand bellows. The antimony being of easy fusion is separated, and runs through the holes of the upper vessel into the inferior one, where it is collected.

To ASSAY ARSENICAL ORES.

THE assay of arsenical ores is made by sublimation in close vessels. Beat the ore into small pieces, and put them into a matrafs and place it in a sand pot, with a proper degree of heat, the arsenic sublimes in this operation, and adheres to the upper part of the vessel; when it must be carefully collected

lected with a view to ascertain its weight. Sometimes a single sublimation will not be sufficient, for the arsenic in many cases will smelt with the ore, and prevent its total volatilization; in which case, it is better to perform the first sublimation with a moderate heat, and afterwards bruise the remainder again, and expose it to a stronger heat.

To ASSAY BISMUTH ORES.

IF the ore be mineralized by sulphur, or sulphur and iron, a previous roasting will be necessary. The strong ores require no roasting, but only to be reduced to a fine powder. Take the assay weight and mix it with half the quantity of calcined borax, and the same of pounded glass; line the crucible with charcoal; melt it as quick as possible; and when it is well melted, take out the crucible, and let it cool gradually. The regulus will be found at the bottom.

To ASSAY COBALTIC ORES.

FREE them as much as possible from earthy matters by well washing, and from sulphur and

arsenic by roasting. The ore thus prepared is mixed with three parts of black flux, and a little decrepitated sea-salt; put the mixture in a lined crucible, cover it, and place it in a forge fire, or in a hot furnace, for this ore is very difficult of fusion.

When the fusion is well made, a metallic regulus is found at the bottom, covered with a scoria of a deep blue colour; as almost all cobalts contain bismuth, this is reduced by the same operation as the regulus of cobalt; but as they are incapable of uniting together, they are always found distinct from each other in the crucible. The regulus of bismuth having a greater specific gravity is always at the bottom, and may be separated by a blow with a hammer.

TO ASSAY NICKEL ORES.

THE ores must be well roasted to expel the sulphur and arsenic, the greener the calx proves during this torrefaction, the more it abounds in the nickel; but the redder it is, the more iron it contains. The proper quantity of this roasted ore is fused in an open crucible, with twice or thrice its weight of black flux, and the whole covered with common salt. By exposing the crucible to the strongest heat of a forge

forge fire, and making the fusion complete, a regulus will be produced. This regulus is not pure, but contains a portion of arsenic, cobalt, and iron. Of the first it may be deprived by a fresh calcination, with the addition of powdered charcoal; and of the second by scorification; but it is with difficulty that it is entirely freed from the iron.

TO ASSAY MANGANESE ORES.

THE regulus is obtained by mixing the calx or ore of manganese, with pitch, making it into a ball, and putting it into a crucible, lined with powdered charcoal, 1-10 of an inch on the sides, and 1-4 of an inch at bottom, then filling the empty space with charcoal dust, covering the crucible with another inverted and luted on, and exposing it to the strongest heat of a forge for an hour or more.

The above are the most approved methods of assaying ores for their particular metals by the dry way; but they are deficient so far as relates to pointing out the different substances, connected with them, because they are always destroyed by the process for obtaining the assay metal. The assay by the moist way is more correct, because, the different substances can be accurately ascertained. The late celebrated

celebrated Bergman first made us acquainted with this method. It depends upon a knowledge of the chemical affinities of different bodies for each other, and must be varied according to the nature of the ore; it is very extensive in its application, and requires great patience and address in its execution. To describe the treatment of each variety of the metallic ores, would take up too much of our room; for a more particular account, I would refer the reader to the 2nd vol. of Bergman's work, where he will find a treatise written expressly on the subject. But to give a general idea, I will describe the procedure on one species of all the different ores.

To ASSAY GOLD *mixed with yellow, or martial*
PYRITES, *by the* HUMID WAY.

DISSOLVE the ore in 12 times its weight of dilute nitrous acid, gradually added; place it in a proper degree of heat; this takes up the soluble parts, and leaves the gold untouched, with the insoluble matrix, from which it may be separated by aqua regia. The gold may be again separated from the aqua regia by pouring æther upon it, the æther takes up the gold, and by being burnt off leaves it in its metallic state. The solution may contain iron,
copper,

copper, manganese, calcareous earth, or argil; if it be evaporated to dryness, and the residuum heated to redness for half an hour, volatile alkali will extract the copper; dephlogisticated nitrous acid, the earths; the acetous, the manganese; and the marine, the calx of iron. The sulphur floats on the first solution, from which it should be separated by filtration.

*To ASSAY vitreous SILVER ORE, by the
HUMID WAY.*

BOIL the ore in dilute nitrous acid, using about 25 times its weight, until the sulphur is quite exhausted. The silver may be precipitated from the solution by marine acid, or common salt. 100 grains of this precipitate contain 75 of real silver; if it contain any gold it will remain undissolved. Fixed alkalies precipitate the earthy matters, and the Prussian alkali will shew if any other metal be contained in the solution.

*To ASSAY vitreous COPPER ORE by the
HUMID WAY.*

MAKE a solution of this ore in 5 times its weight of concentrated vitriolic acid, and boil it to dryness;
add

add as much water as will dissolve the vitriol thus formed; to this solution add a clean bar of iron, which will precipitate the whole of the copper in its metallic form. If the solution be contaminated with iron, the copper must be re-dissolved in the same manner, and precipitated again. The sulphur may be separated by filtration.

TO ASSAY IRON ORES *by the* HUMID WAY.

TO assay the calciform ores, which do not contain much earthy or stony matter, they must be reduced to a fine powder, and dissolved in the marine acid; and precipitated by the Prussian alkali. A determinate quantity of the Prussian alkali, must be tried previously to ascertain the portion of iron, which it will precipitate, and the estimate made accordingly. If the iron contain any considerable portion of zinc or manganese, the precipitate must be calcined to redness, and the calx treated with dephlogisticated nitrous acid, which will then take up only the calx of zinc; when this is separated, the calx should again be treated either with nitrous acid, with the addition of sugar, or with the acetous acid, which will dissolve the manganese, if any; the remaining calx of iron may then be dissolved by the marine acid, and precipitated

cipitated by the mineral alkali; or it may be farther calcined, and then weighed.

To ASSAY TIN ORES, *by the* HUMID WAY.

THE assay of tin ores in the liquid way, was looked upon as impracticable, till Bergman devised the following method, which is generally successful. Let the tin ore be well separated from its stony matrix, by well washing, and reduced to the most subtle powder; digest it in concentrated oil of vitriol, in a strong heat for several hours, then, when it is cooled, add a small portion of concentrated marine acid, and suffer it to stand for one or two hours; then add water, and when the solution is clear, pour it off, and precipitate it by fixed alkali. 131 grains of this precipitate well washed and dried, are equivalent to 100 of tin in its reguline state, if the precipitate consist of pure tin; but if it contain copper or iron, it must be calcined in a red heat for an hour, and then digested in nitrous acid, which will take up the copper; and afterwards in marine acid, which will separate the iron.

To ASSAY LEAD ORES *by the* HUMID WAY.
GALENA.

DISSOLVE the ore by boiling it in dilute nitrous acid; the sulphur, insoluble stony parts, and calx of iron will remain. The iron may be separated by digestion, in the marine acid; and the sulphur by digestion, in caustic fixed alkali. The nitrous solution contains the lead and silver, which should be precipitated by the mineral fixed alkali, and the precipitate well washed in cold water, dried and weighed. Digest it in caustic volatile alkali, which will take up the calx of silver; the residuum being again dried and weighed, gives the proportion of the calx of lead. 132 grains of which are equal to 100 of lead in its metallic state. The difference of weight of the precipitate before and after the application of the volatile alkali, gives the quantity of silver, 129 grains of which are equal to 100 of silver in its metallic state.

To ASSAY MERCURIAL ORES *by the* HUMID WAY. NATIVE CINNABAR.

THE stony matrix should be dissolved in nitrous acid, and the cinnabar being disengaged, should be
boiled

boiled in 8 or 10 times its weight of aqua regia, composed of 3 parts nitrous, and 1 of marine acid. The mercury may be precipitated in its running form by zinc.

To ASSAY the ORES of ZINC, by the HUMID WAY. CALAMINE.

DISTILL vitriolic acid over calamine to dryness; the residuum must be lixiviated in hot water; what remains undissolved is siliceous earth: To the solution add caustic volatile alkali, which precipitates the iron and argil, but keeps the zinc in solution; as it is soluble in vitriolic ammoniac. The precipitate must be re-dissolved in vitriolic acid, and the iron and argil separated.

To ASSAY ANTIMONIAL ORES by the HUMID WAY. ARSENICATED ANTIMONY.

DISSOLVE the ore in aqua regia, both the regulus and arsenic remain in the solution, the sulphur is separated by filtration. If the solution be boiled with twice its weight of strong nitrous acid, the regulus of antimony will be precipitated by dephlogistication, and the arsenic converted into an acid, which may be obtained by evaporation to dryness.

To ASSAY ARSENICAL ORES, *by the* HUMID WAY. REALGAR.

DIGEST the ore in marine acid, adding the nitrous by degrees to help the solution. The sulphur will be found on the filter; the arsenic will remain in the solution, and may be precipitated in its metallic form by zinc, adding spirit of wine to the solution.

To ASSAY BISMUTH ORE, *by the* HUMID WAY.

BISMUTH is easily soluble in nitrous acid or aqua regia. Its solution is colourless, and is precipitable by the addition of pure water. 118 grains of the precipitate from nitrous acid, well washed and dried, are equal to 100 of bismuth in its metallic form.

To ASSAY COBALTIC ORES, *by the* HUMID WAY. GREY COBALT ORE.

MAKE a solution of the ore in nitrous acid, or aqua regia, and evaporate to dryness; the residuum treated with the acetous acid, will yield to it the cobaltic part; the arsenic should be first precipitated by the addition of water.

To

To ASSAY NICKEL ORES by the HUMID WAY. NUPFERNICKEL.

THE assay of these ores in the humid way, is as yet very imperfect. By solution in nitrous acid, it is freed from its sulphur; and by adding water to the solution, bismuth, if any, may be precipitated; as may silver if contained in it, by the marine acid; and copper, when any by iron. To separate cobalt from nickel, when the cobalt is in considerable quantity, Gerhard advises to drop a saturated solution of the roasted ore in nitrous acid into liquid volatile alkali; the cobaltic part is instantly re-dissolved, and assumes a garnet colour; when filtered a grey powder remains on the filter, which is the nickel. The cobalt may be precipitated from the volatile alkali by any acid.

To ASSAY MANGANESE ORES by the HUMID WAY.

THE ores should be well roasted to dephlogistate the calx of manganese and iron, if any, then treated with dephlogistated nitrous acid to dissolve the earths. The residuum should then be treated with nitrous acid and sugar, by which means a colourless solution of manganese will be obtained, and likewise of the iron, if any. Precipitate with the

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Prussian alkali, and digest the precipitate in pure water; the Prussian manganese will be dissolved, and the Prussian iron remain undissolved.

In the assay of the metallic ores above mentioned by the humid way, the circumstances attending it are very various, yet with a proper attention to the examples given, the assayer will be enabled by his own reflexion to adapt the proper means for assaying those ores which are not noticed.

In assaying, we are at liberty to use the most expensive materials to effect our purpose, hence, the use of different saline fluxes; but in the working at large, such expensive means cannot be applied; as by such processes the inferior metals would be too much enhanced in value, especially in working very poor ores. In consequence of which, in smelting works, where the object is the production of metals in the great, cheaper additions are used; such as limestone, feldt-spar, fluor-spar, quartz, sand, slate, and flags. These are to be chosen according to the different views of the operator, and the nature of the ores. Thus, iron ores on account of the argillaceous earth they contain, require calcareous additions, and the copper ores, rather flags or vitrescent stones, than calcareous earth. The general procedure is the same as assaying in the dry way, and the operations carried on in the smelting works, depend on the very same principles.

PART II.
OF
METALS
AND
METALLIC COMPOUNDS.



OF METALS AND METALLIC COMPOUNDS.

THE working of ores is to extract their metals.

The metals at present accurately known, are 17 in number, and may be thus arranged:

NOBLE METALS.	INTERMEDIATE METAL.	QUICKSILVER.	BASE METALS.	MALLEABLE.
				NOT MALLEABLE.
Platina				Copper
Gold				Lead
Silver		Quicksilver		Iron
				Zinc
				Manganese
				Nickel
				Bismuth
				Antimony
				Cobalt
				Acidifiable
				Arsenic
				Tin*
				Molybdena
				Tungsten

To this list of metallic substances have been added, First, Siderite. Mr. Monnet first distinctly mentioned this substance in his mineralogy, printed in

* Tin when it is reduced is very malleable.

1779. It was afterwards developed in its principal properties by Meyer and Bergman.

It is principally found in iron of the first fusion, or cast iron, and in the ores of cold short iron. To obtain it, the cast iron must be dissolved in dilute vitriolic acid; the solution after standing some hours will deposit a white calx, if siderite be contained in it, one pound of the iron will sometimes afford 12 drachms of this calx, whose natural colour is white, but it is generally tinged brown or yellow, from a mixture of the calx of iron. Bergman purifies it, by abstracting the nitrous acid over it, which dephlogisticates the iron, and leaves the siderite soluble in the mineral acids, but not in the acetous.

It is reduced to a regulus by melting it with half its weight of borax, lining the crucible with charcoal dust and clay, and exposing it to a forge fire for 3-4 of an hour. The regulus is of a steel grey color, and exceedingly brittle; not magnetic in small pieces, but slightly so when powdered. But Meyer and Scheele have since proved that siderite is only iron combined with phosphoric acid.

Secondly, Saturnite. It is said by Mr. Monnet to be found in the lead mines of Poullaoven in Brittany, and is separated from the lead ore during torrefaction. It refuses to mix with lead when in fusion. It is not at present well known.

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But an analysis of saturnite has since been given by Haffenfratz and Giroud, in the *Journal de Physique*, for January 1786, from which it is said to consist of

	lb.	oz.	gros.	grs.	
Lead —	40	13	6	6	French weight
Copper	31	4	0	0	
Iron —	4	1	2	0	
Silver —	0	2	1	66	
Sulphur	23	10	6	0	

Monnet denies that this alloy is the substance he noticed.

Thirdly, A new semi-metal has been lately discovered by Mr. Klaproth, of Berlin, in the Pechblende, an ore containing silver and zinc, mineralized by sulphur, and in the green Saxon glimmer. The discoverer calls it uranite. It is more difficult to reduce than manganese, it has little metallic splendor, is moderately hard, and gives porcelain a yellow colour.

On METALS.

UNDER this general term, we comprehend not only the metals, properly so called, but also the

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femi-metals. They are divided into two classes, viz. First, noble, which consists of platina, gold, and silver; and secondly, base, which consists of copper, lead, iron, tin, bismuth, nickel, arsenic, antimony, cobalt, manganese, zinc, molybdena, Tungsten, and quicksilver. Metallic matters form a class not very numerous, but of very great importance in chemistry, medicine, and the arts.

In searching for characters to distinguish metals from other substances, their opacity and specific gravity must appear striking. They are the heaviest bodies in nature, as proved by hydrostatical experiments, though they differ much among themselves in this respect; they always entirely oppose the passage of the rays of light, and reflect a part of them from their surfaces; if they be exposed to the fire, they fuse with more or less difficulty, and on cooling recover their former consistence. They sometimes assume after a perfect fusion, and being suffered to cool gently, regular arrangements, which are peculiar in every different metallic substance.

A TABLE of the specific Gravities of the different METALS, and of the degree of Heat at which they severally fuse, reduced to Fahrenheit's Scale by Bergman.

Specific Gravity.		Metals.	Melt.
Fine Gold	19.640	Platina	—
Standard Gold	18.888	Fine Gold	1031°
Guinea Gold	17.793	Silver	1000°
Moidore Gold	17.140	Quicksilver	40°
Platina	21.000	Lead	595°
Silver	10.552	Copper	1450°
Quicksilver	14.110	Iron	1601°
Lead	11.352	Tin	415°
Copper	8.876	Bismuth	490°
Iron	7.80	Nickel	1061°
Tin	7.264	Arsenic	—
Bismuth	9.670	Cobalt	1601°
Nickel pure	9.000	Zinc	699°
Arsenic	8.308	Antimony	809°
Cobalt	7.700	Manganese	very great
Zinc	6.862		
Antimony	6.860		
Manganese	6.850		

A TABLE shewing the Order of Malleability, and the Degree of Tenacity of the different METALS, with the Quantity of Phlogiston they contain.

Malleability.	Degree of Tenacity.	Quantity of Phlogiston.
Gold	500	Platina 756
Silver	270	Gold 394
Copper	$299\frac{1}{2}$	Iron 342
Tin	$49\frac{1}{2}$	Copper 312
Iron	450	Cobalt 270
Lead	$29\frac{1}{4}$	Manganese 227
Zinc		Zinc 182
		Nickel 156
		Antimony 120
		Tin 114
		Arfenic 109
		Silver 100
		Mercury 74
		Bismuth 57
		Lead 43

Metals possess a certain brilliancy and splendor peculiar to themselves, which chemists call metallic lustre, this property seems intimately connected with their opacity. When exposed to the action of heat and air, all of them, except gold and silver, lose that splendor, and are converted into calces, in which state, they possess many of the properties of the simple earths. Other qualities peculiar to metallic substances,

substances, are malleability and ductility; by which is meant, first, the power of extending their surfaces, by passing them through rollers, by the hammer, &c. and secondly, their capability of being drawn into wire. They are all soluble in acids, but some of them require particular treatment. Metals are heated more speedily, and cool again more quickly, than any other bodies exposed to the same temperature. From the experiments of Dr. Ingenhouz, it appears that their power of conducting heat is in the following order, viz. silver, copper, gold, tin, iron, steel, lead.

Various have been the opinions of chemists, respecting the constituent parts of metals; three of the most modern and best received will be mentioned, viz.

First, That metals are composed of peculiar earths united to phlogiston.

Secondly, That they are composed of peculiar acids united to phlogiston; and

Thirdly, That with respect to our present knowledge, metals ought to be looked upon as simple substances, composed of homogeneous parts.

Chemists in their experiments on metals, found, that by exposing them to the action of heat, they underwent a change, by which they acquired new properties. This change they conjectured to proceed from the separation of a volatile principle,
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from the more fixed part or calx, because, on the addition of any substance which contained this volatile principle or phlogiston, it united with the calx of the metal, and perfectly reduced it. This principle, though admitted by chemists, never could be exhibited in any form; to account for which, it was said that immediately on its extrication, it united itself to other bodies, and formed a new compound, but its existence and identity, were proved by making a solution of copper in dilute vitriolic acid, and precipitating the copper in its metallic form by the addition of iron; the phlogiston of the iron during its solution united with the calx of the copper, and revive it with all its metallic lustre.

The second opinion is founded, on procuring radical acids, by dissipating the phlogiston of some of the imperfect metals; for after the metals are acidified, they become so fixed that no farther change can be procured; but on the addition of any phlogistic substance, these acids are converted into metals.

The third opinion is supported by Mr. Lavoisier, and all the French academicians. They deny that metals contain the principle of phlogiston, and look upon it as a creature of the imagination. It was from the following experiment, that Mr. Lavoisier first proposed his doubts on that principle; he dissolved a quantity of quicksilver in a determinate
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quantity of nitrous acid, after the solution, he distilled to dryness, when he found a red precipitate, and by urging the fire farther, he recovered quicksilver without any addition, in a metallic state; on examination of the vapour in the receiver, he found it to be nitrous air, and what was expelled from the red precipitate, was the base of dephlogisticated air, from which experiment he inferred, first, that from the solution of the quicksilver in the nitrous acid, the only change which took place, was the decomposition of the nitrous acid. Secondly, that the acid is composed of two parts, viz. nitrous air, and the base of dephlogisticated air; and thirdly, that the calcination of the quicksilver, was in consequence of the metal depriving the acid of its acidifying principle, or dephlogisticated air, because, by destroying the affinity between the precipitate and dephlogisticated air, the metal was restored.

This experiment was corroborated by others, particularly by calcining metals with a burning glass, in a determinate quantity of air, when it was found that the calcination proceeded in proportion to the quantity of pure air which was contained, and that when the metal had abstracted the whole quantity of pure air, no farther calcination could be promoted.

The phlogistians in answer to the first experiment, observe, that Mr. Lavoisier has not proved that the quicksilver during its solution gave out no phlogiston,

phlogiston, which uniting with the basis of the nitrous acid, formed the nitrous air; on the contrary, Mr. Kirwan has endeavoured to prove that phlogiston is a constituent part of the nitrous air; if so, the metal must have given out phlogiston during its solution, or else no nitrous air could have been produced. As a proof that metals give out phlogiston during their solution, the following experiment is strongly urged, viz. make a solution of iron in dilute vitriolic acid, during the solution a vapor is extricated, which is called inflammable air; upon examination of this vapor, it possesses all the properties of Stahl's phlogiston. In this experiment the only change which takes place is in the metal, because the vitriolic acid which is united to the calx of the metal, requires the same quantity of alkali to saturate it, as an equal portion of uncombined dilute vitriolic acid would, and on the immediate application of an alkali it leaves the iron, and unites with it, forming a vitriolated tartar, which could not be the case if the acid were altered during the solution. This fact reduced the French academicians into a dilemma, from which they could not for some time extricate themselves.

During this embarrassment, Mr. Cavendish, by taking the electric spark in certain proportions of dephlogisticated and inflammable airs, found, that by an union so promoted, the product was water.

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The academicians taking advantage of this discovery, applied it for the elucidation of their own system, and then easily accounted for the production of inflammable air, from a solution of iron in the dilute vitriolic acid, by declaring that the water which diluted the vitriolic acid was decomposed, the dephlogisticated air uniting with the calx of the iron, while the inflammable air was set at liberty. To support which opinion, Mr. Lavoisier mixed some iron filings with water, and whatever was extricated was caught by passing through quicksilver; the vapor was found to be inflammable air; produced, as Mr. Lavoisier supposed, from the decomposition of that portion of water necessary to calcine the iron. As the component parts of water had been ascertained by Synthesis, before he could establish his opinion with the least degree of plausibility, it became absolutely necessary that he should shew, that water could be decomposed, for it never had been, and therefore whatever he advanced was merely conjectural. To establish which, an experiment was made before some of the academicians, by passing water drop by drop through a red hot gun barrel, properly prepared, and with an apparatus appended to collect whatever might pass during the process. The vapour extricated was found to be inflammable air, and the internal surface of the barrel was in a state of calcination. By weighing the
barrel

barrel previous to and after the experiment, the weight gained by the calcination was ascertained, which added to the inflammable air, and to the remaining water, made up the exact weight of the water before the experiment. But to make this experiment as unexceptionable as possible, they took the same weight of dephlogisticated air as the gun barrel had gained, and added it to the same inflammable air which had been collected, and by exposing them in a proper apparatus to a red heat, they recovered the water which had been decomposed. This experiment was looked upon as decisive, and their opinion as firmly established. Admitting the decomposition and re-composition of water to be fully proved in a red heat, how can this experiment be applied with any force to the decomposition of water, in a solution of iron in the dilute vitriolic acid? Bodies will unite together with different degrees of cohesion, and form results accordingly; but it requires always the same degree of power to produce invariable compounds; the nitrous acid unites with different portions of phlogiston, and forms the yellow, the orange, or the green coloured acid. It must be supposed that the nitrous acid at those marked varieties, must exert different degrees of attraction for phlogiston, which is analogous to a well known chemical fact, that the facility with which bodies are decomposed, is according to the proportion of their
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constituent parts; now, as the different coloured nitrous acid is influenced, by the different degrees of cohesion between its constituent parts, each portion and power producing a distinct variety, so different portions of dephlogisticated and inflammable airs, will form distinct varieties, according to the proportion of constituent parts and power of attraction between them, so that one marked variety, viz. water, can only be produced by the power resulting from exposing the parts to a red heat; and if different varieties do result from such circumstances, different degrees of power are necessary for their decomposition; and as water has been only decomposed by a red heat, aided by the attraction of the iron to the oxigène, we do not see how water can be decomposed with only the heat produced, by the solution of iron in vitriolic acid, assisted by no greater attraction than when the decomposition required a red heat!

On G O L D.

GOLD is a metal moderately hard, of a bright yellow color when pure. It acquires rigidity beneath the hammer, and becomes soft again by annealing; which is performed by heating it red hot in
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charcoal, and suffering it to cool gradually. Mixed with different alloys its color varies. It is the most ductile of all the metals, as well as the most tenacious. A wire 1-10 of an inch in diameter, will support a weight of 500lb. without breaking. The specific gravity of fine gold is 19.640. When exposed to the fire it reddens long before it melts, when at the point of fusion it takes a sea green hue. If it be ever so long exposed to fire, it undergoes no alteration. Air and water have no action upon it, neither has sulphur nor fixed alkali. Its proper solvent is aqua regia, or dephlogisticated marine acid, though liver of sulphur, by a particular treatment, will dissolve it.

The principal uses of gold are well known. It is found useful for various ornaments, from its lustre, beauty, and indestructible quality. When applied by the art of gilding, much external beauty, neatness, and richness, is given to many utensils and toys. Its calx gives a fine colour for enamel, glass, and porcelain painting. It is likewise used for different coins.

To dissolve Gold in Aqua Regia.

TAKE an aqua regia, composed of 2 parts of nitrous acid, and 1 of marine acid, or of 1 part of sal ammoniac, and 4 parts of aqua fortis; let the gold be granulated; put into a sufficient quantity of this menstruum,

struum; and exposed to a moderate degree of heat. During the solution an effervescence takes place, and it acquires a beautiful yellow colour, which becomes more and more intense, till it has a golden, or even orange colour. When the menstruum is saturated it is very clear and transparent.

Gilding by dissolving Gold in Aqua Regia.

FINE linen rags are soaked in a saturated solution of gold in aqua regia, gently dried; and afterwards burnt to tinder. The substance to be gilt must be well polished; a piece of cork is first dipped into a solution of common salt in water, and afterwards into the tinder, which is well rubbed on the surface of the metal to be gilt, and the gold appears in all its metallic lustre.

Gilding of Iron or Steel with a Solution of Gold.

MAKE a solution of eight ounces of nitre and common salt, with five ounces of crude alum in a sufficient quantity of water; dissolve half an ounce of gold thinly plated and cut; and afterwards evaporate to dryness. Digest the residuum in rectified spirit of wine or æther, which will perfectly abstract the gold. The iron is brushed over with this solution, and becomes immediately gilt.

For Grecian Gilding.

EQUAL parts of sal ammoniac and corrosive sublimate, are dissolved in spirit of nitre, and a solution of gold made with this menstruum. The silver is brushed over with it, which is turned black, but on exposure to a red heat, it assumes the colour of gold.

Theory of Gilding with a Solution of Gold in Aqua Regia.

WHEN gold is dissolved in aqua regia, and the solution applied to another metal, the aqua regia immediately attacks that metal, and dissolves a portion of it; while its phlogiston revives the calx of gold, which is attached to the surface by the attraction of cohesion subsisting between the metals. If the phlogiston be in a proper quantity, the gold appears with its metallic lustre; but if super-abundant, it appears black; till by heat a part is evaporated, and then the gold appears with all its brilliancy.

If a solution of gold in aqua regia be evaporated, crystals will be formed, which are called CRYSTALS OF GOLD.

Gold may be dissolved in liver of sulphur in the dry way, by which it becomes soluble in water. The method is as follows, viz. make a liver of sulphur, by fusing equal parts of sulphur and fixed alkali in

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a crucible with a moderate heat, till the mass congeals and acquires a red colour; to which must be added gold leaves, and the whole fused quickly; the gold will be attacked by the liver of sulphur, and soon disappear. If the liver of sulphur thus impregnated with gold be dissolved in water and filtered, the gold will pass the filtering paper in a state of solution.

This gold may be recovered from the solution, by the addition of any acid, which seizes upon the alkali, and precipitates the gold and sulphur of a yellow colour. On the application of heat, the sulphur burns away and leaves the metal pure.

Gold dissolved in aqua regia, may be precipitated both by fixed and volatile alkali, but with this difference; viz. that the calx produced by fixed alkalies, does not explode when applied to heat; but, on the contrary, if the precipitate be made with volatile alkali, and afterwards well washed and dried, on exposure to heat it goes off with a very great explosion. This is called FULMINATING GOLD, and is one of the most curious phenomena in chemistry.

Gold has an affinity to all the metals, particularly quicksilver, by which union artists gild by amalgamation.

To make the Amalgam.

A quantity of quicksilver is put into a crucible or iron ladle, which is lined with clay, and exposed to heat till it begins to smoke. The gold to be mixed should be previously granulated and heated red hot; when it should be added to the quicksilver, and stirred about with an iron rod till it is perfectly dissolved. If there should be any superfluous mercury, it may be separated by passing it through clean soft leather; and the remaining amalgam will have the consistence of butter, and contain about three parts of mercury to one of gold.

To gild by Amalgamation.

THE metal to be gilt is previously well cleaned on its surface by boiling it in a weak pickle, which is a very dilute nitrous acid. A quantity of aqua fortis is poured into an earthen vessel, and quicksilver put therein; when a sufficient quantity of mercury is dissolved, the articles to be gilt are put into the solution and stirred about with a brush till they become white. This is called quicking. But, as during quicking by this mode, a noxious vapour continually arises, which proves very injurious to the health of the workmen; they have adopted another method, by which, they, in a great measure avoid that

that danger. They now dissolve the quicksilver in a bottle containing aqua fortis, and leave it in the open air during the solution, so that the noxious vapor escapes into the air. Then they pour a little of this solution into a basin, and with a brush dipped therein, stroke over the surface of the metal to be gilt, which immediately becomes quicked; the amalgam is now applied by one of the following methods, viz. first, by proportioning it to the quantity of articles to be gilt, and putting them into a hat together, working them about with a soft brush, till the amalgam is uniformly spread; or, secondly, by applying a portion of the amalgam upon one part, and spreading it on the surface, if flat, by working it about with a harder brush. The work thus managed is put into a pan, and exposed to a gentle degree of heat; when it becomes hot, they frequently put it into a hat, and work it about with a painter's large brush, to prevent an irregular dissipation of the mercury; till at last the quicksilver is intirely dissipated by a repetition of the heat, and the gold is attached to the surface of the metal. This gilt surface is well cleaned by a wire brush, and then artists exalt the color of the gold by the application of various compositions; this part of the process is called COLORING. I have selected the following, which are as good as can be obtained for the purpose.

A Wax to exalt the color of red Gold.

TO four ounces of melted yellow wax, add in fine powder, one ounce and a half of red oker; one ounce and a half of verdigrise, calcined till it yields no fumes; and half an ounce of calcined borax, mix them well together. It is necessary to calcine the verdigrise, or else by the heat applied in burning off the wax, the vinegar becomes so concentrated as to corrode the surface, and make it appear specked.

To exalt the color of yellow Gold.

SALTPETRE six ounces, green copperas two ounces, white vitriol and alum of each one ounce. If it be wanted redder, a small portion of blue vitriol must be added. These are to be well mixed, and dissolved in water as the colorish is wanted.

To exalt the color of green Gold.

TAKE saltpetre one ounce ten dwts. sal ammoniac, one ounce four dwts. Roman vitriol one ounce four dwts. and verdigrise eighteen dwts. mix them well together, and dissolve a portion of it in water as occasion requires.

The work must be dipped in these compositions; applied to a proper heat to burn them off; and then they should be quenched in water or vinegar.

Gilding

Gilding in Colors.

THE principal colors of gold for gilding are red, green, and yellow. These should be kept in different amalgams. The part which is to remain of the first colour, is to be stopped off with a composition of chalk and glue; the variety required is produced, by gilding the unstopped parts with the proper amalgam, according to the usual mode of gilding.

Sometimes the amalgam is applied to the surface to be gilt, without any quicking, by spreading it with aqua fortis; but this depends on the same principle as a previous quicking.

Theory of gilding by Amalgamation.

WHEN a solution of quicksilver in the nitrous acid is applied to the surface of copper, a decomposition takes place; the nitrous acid dissolves the copper, and precipitates a coat of quicksilver; so when the amalgam is applied without a previous quicking, a part of the aqua fortis dissolves a portion of quicksilver in the amalgam, which coming into contact with the copper, precipitates the mercury. The amalgam being now applied, is easily diffused over the whole surface, by the mutual attraction subsisting between the metals; but on the application of heat,
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the quicksilver being so very volatile, is evaporated away, while it leaves the gold as being a very fixed body, attached to the copper by the attraction of cohesion.

Gilding by amalgamation is principally used for copper and its various compounds.

Iron cannot be gilt by amalgamation, unless upon a precipitated coat of copper. There is another mode of gilding, particularly used for that purpose, viz. by leaf gold. The iron is to be heated in a clear fire till it becomes blue, a leaf of gold is applied upon it, and rubbed down with a fine burnisher; it is found to adhere closely. This may be repeated till you have fixed what number of leaves you please.

To separate the Gold from gilt Copper.

APPLY a solution of borax in water to the gilt surface with a fine brush; and sprinkle over it some fine powdered sulphur. Make the piece red hot, and quench it in water. The gold may be easily wiped off with a scratch-brush, and recovered by testing it off with lead.

Gold is taken from the surface of silver by spreading over it a paste made of powdered sal ammoniac with aqua fortis, and heating it till the matter smokes and is nearly dry. When the gold may be separated by rubbing it with a scratch brush.

Leaf-gold may be applied to all vitrified matters, whose surfaces are very smooth, consequently capable of a very perfect contact with it. This gilding is the more perfect, as the gold is more exactly applied to the surface of the glass; the pieces are then exposed to a certain degree of heat, and burnished slightly to give them adhesion and lustre. Books, Wood, &c. may be gilt with leaf-gold, with the assistance of adhesive varnishes, which, when dry, will bear to be burnished.

OF SILVER.

SILVER is a brilliant white metal, indestructible either by fire or water; without taste or smell. Excepting gold, it is the most malleable of all the metals; more elastic and sonorous than gold; becomes rigid by hammering, and is softened by annealing. Its specific gravity is 10,552. A wire 1-10 of an inch will support a weight of 270lb. without breaking. By long exposure to air it absorbs phlogiston, and then it is said to be tarnished. It has been exposed to a glass-house furnace for a month, without the heat producing any alteration, except a small loss of weight, which probably proceeded from the silver being impure. All the acids dissolve it with more

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or less facility. Vitriolic acid when concentrated and heated dissolves it, and forms VITRIOL OF SILVER; the marine acid when very hot will dissolve it, but in a small quantity. The nitrous acid is its best solvent; it dissolves it perfectly, and without difficulty. The crystals formed by evaporating a small portion of the nitrous acid, are called LUNAR CRYSTALS, which will deflagrate by putting them on a burning coal like nitre. These crystals melted in a crucible, and then poured into a small cylindrical mould, form a powerful caustic, called LAPIS INFERNALIS, OR LUNAR CAUSTIC. Silver is precipitated from its solution in nitrous acid by alkalies, copper, iron, &c. as well as by the vitriolic and marine acids. If in a solution of silver in the nitrous acid, you drop a few drops of oil of vitriol, the vitriol seizes the silver, and falls down in a white precipitate, which is the VITRIOL OF SILVER; and, if in the same solution, you drop a little of the marine acid, the marine acid seizes the silver, and forms a thick coagulum, which is called LUNA CORNEA.

Fixed alkalies precipitate silver from its solution in the acids, but they appear to have no action on the calx; whereas the volatile alkali will precipitate it, and redissolve the calx, particularly in a caustic state.

The most astonishing substance in all chemistry is produced from silver, discovered by Mr. Berthollet, and called by him FULMINATING SILVER. It is prepared

as follows: dissolve cupelled silver in pure or dephlogisticated nitrous acid. Precipitate the silver with lime-water; then decant the liquor, and expose the precipitate for the space of three days to the air. Mr. Berthollet imagines, that at this period of the experiment, the presence of light may have an influence on its success. To this calx when dry, add caustic volatile alkali, it will take the form of a black powder. Decant the liquor, and let the powder dry in the air. This is fulminating silver, which cannot bear to be touched by any cold body without fulminating; so that it must remain in the capsule in which it was dried. The volatile alkali used in the preparation, being boiled in a thin matraass, forms crystals, which being touched under the liquor, suddenly detonate and break the vessel.

Arbor Dianæ, or Philosophical Tree.

THIS is a matter of curiosity only. Make an amalgam of silver and mercury, and dissolve it in a sufficient quantity of pure aqua fortis; dilute it in about four times its weight of distilled water, and cork it down quite tight. When it is wanted for use a little of it is poured into a bottle, and a small piece of an amalgam of gold or silver put in, when it must remain at rest; small filaments soon shoot from the amalgam, which branch out on all sides, and take the form of shrubs.

Silver

Silver is applied to the surfaces of the different metals by various means, though the general processes are denominated, either silvering or plating.

To Silver in the cold Way.

TAKE two drachms of each, tartar and common salt; half a drachm of alum, and 20 grains of silver precipitated from the nitrous acid by copper; make them into a paste with a little water. This is to be rubbed on the surface to be silvered with a cork, &c.

Another Method.

DISSOLVE pure silver in aqua fortis, and precipitate the silver with common salt, make this precipitate into a paste by the addition of a little more common salt, and cream of tartar. It is applied as in the former method.

Silvering by heat.

DISSOLVE an ounce of pure silver in aqua fortis, and precipitate it with common salt, to which add half a pound of sal ammoniac, sandiver, and white vitriol, and a quarter of an ounce of sublimate.

Another Preparation for silvering by heat.

DISSOLVE an ounce of pure silver in aqua fortis, and precipitate it with common salt, and add,
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after washing; six ounces of common salt, three ounces of each sandiver and white vitriol, and a quarter of an ounce of sublimate.

These are to be ground into a paste upon a fine stone with a mullar, the substance to be silvered, must be rubbed over with a sufficient quantity of the paste, and exposed to a proper degree of heat. When the silver runs it is taken from the fire, and dipped into weak spirit of salt to clean it.

Silvering on gilt Work by Amalgamation.

SILVER will not attach itself to any metal by amalgamation, unless it be first gilt. The process is the same as gilding in colours, only no acid should be used.

On plating of Copper Ingots.

THE principal difficulties in plating copper ingots, are, to bring the surfaces of the copper and silver into fusion at the same time; and to prevent the copper from scaling; for which purposes fluxes are used. The surface of the copper on which the silver is to be fixed, must be made flat by filing, and should be left rough. The silver is first annealed, and afterwards pickled in weak spirit of salt; it is planished, and then scraped on the surface to be fitted on the copper. These prepared surfaces are anointed with a solution of borax, or strewed with fine powdered

dered borax itself; and then confined in contact with each other by binding wire. When they are exposed to a sufficient degree of heat, the flux causes the surfaces to fuse at the same time, and after they become cold, they are found firmly united.

Copper may likewise be plated by heating it, and burnishing leaf-silver upon it, so may iron and brass. This process is called French plating.

To strip plated Copper.

THIS process is applied to recover the silver from the plated metal, which has been rolled down for buttons, toys, &c. without destroying any large portion of the copper. For which purpose a menstruum is composed of three pounds of oil of vitriol, one ounce and a half of nitre, and one pound of water. The plated metal is boiled in it, till the silver be dissolved, and then the silver is recovered by throwing common salt into the solution.

To make an Essay of plated Metal.

TAKE a determinate quantity of the plated metal; put it into an earthen vessel with a sufficient quantity of the above menstruum; and place it in a gentle heat. When the silver is stripped it must be collected with common salt; the calx must be tested off with lead; and the estimate made according to the product of silver.

On

On parting.

By this process gold and silver are separated from each other. These two metals equally resisting the action of fire and of lead, must therefore be separated by other means. This is effected by different menstrua. Nitrous acid, marine acid, and sulphur, which cannot attack gold, operate upon silver; and these are the principal agents employed in this process.

Parting by nitrous acid is most convenient, consequently most used, indeed it is the only one employed by goldsmiths. This is called simply parting.

That made by the marine acid is by cementation, and is called concentrated parting; and parting by sulphur is made by fusion, and called DRY PARTING.

First, PARTING BY AQUA FORTIS. This process cannot succeed unless we attend to some essential circumstances. First, The gold and silver must be in a proper portion, viz. the silver ought to be three parts to one of gold; though a mass containing two parts of silver to one of gold may be parted. To judge of the quality of the metal to be parted, assayers make a comparison upon a touchstone, between it and certain needles composed of gold and silver, in graduated proportions, and properly marked; which

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are called PROOF NEEDLES. If this trial shews that the silver is not to the gold as three to one; the mass is improper for the operation, unless more silver be added; and secondly, that the parting may be exact, the aqua fortis must be very pure, especially free from any mixture of the vitriolic or marine acid. For if this were not attended to, a quantity of silver proportionable to these two foreign acids would be separated during the solution; and this quantity of vitriol of silver, or luna cornea would remain mingled with the gold, which consequently would not be entirely purified by the operation.

The gold and silver to be parted ought previously to be granulated, by melting it in a crucible; and pouring it into a vessel of water, giving the water at the same time a rapid circular motion, by quickly stirring it round with a stick. The vessels generally used in this operation are called parting glasses, which ought to be very well annealed, and chosen free from flaws; as one of the chief inconveniencies attending the operation is, that the glasses are apt to crack by exposure to cold, or even when touched by the hand. Some operators secure the bottom of the glasses by a coating composed of a mixture of new flaked lime with beer and whites of eggs spread on a cloth, and wrapped round the glasses at the bottom; over which they apply a composition of clay and hair. The parting glasses should be placed

placed in vessels containing water supported by tripods, with a fire under them; because if a glass should break the contents are caught in the vessel of water. If the heat communicated to the water be too great, it may be properly regulated by pouring cold water gradually and carefully down the side of the vessel. Into a parting glass fifteen inches high, and ten or twelve inches wide at the bottom; placed in a copper pan, twelve inches wide at bottom; fifteen inches wide at top, and ten inches high; Schlutter usually put about eighty ounces of metal, with twice as much aqua fortis.

The aqua fortis ought to be so strong as to act sensibly on silver when cold, but not so strong as to act violently. Little heat should be applied at first, as the liquor is apt to swell and rise over the vessel; but when the acid is nearly saturated, the heat may safely be increased. When the solution ceases, which is known by the effervescence discontinuing, the liquor is to be poured off; if any grains appear entire, more aqua fortis must be added, till the silver be all dissolved. If the operation has been performed slowly, the remaining gold will have the form of distinct masses. The gold appears black after parting, probably from the phlogiston of the nitrous acid; its parts have no adhesion together; because the silver dissolved from it has left many interstices. To give them more solidity, and improve their color, they are

put into a test under a muffle, and made red hot, after which they contract and become more solid, and the gold resumes its color and lustre. It is then called **GRAIN GOLD**. If the operation has been performed hastily, the gold will have the appearance of black mud or powder, which after well washing, must be melted.

The silver is usually recovered by precipitating it from the aqua fortis by means of pure copper. If the solution be perfectly saturated, no precipitation can take place, till a few drops of aqua fortis be added to the liquor. The precipitate of silver must be well washed with boiling water, and may be fused with nitre, or tested off with lead.

Secondly, **PARTING BY CEMENTATION**. A cement is prepared, composed of four parts of bricks powdered and sifted; of one part of green vitriol calcined till it becomes red; and of one part of common salt; this is to be made into a firm paste with a little water or urine. It is called the **CEMENT ROYAL**.

The gold to be cemented is to be reduced into plates as thin as money. At the bottom of the crucible or cementing pot, a stratum of cement, of the thickness of a finger is to be put, which is to be covered with plates of gold; and so the strata are placed alternately. The whole is to be covered with a lid, which is to be luted with a mixture of clay and sand. This pot must be placed in a furnace, or oven, heated gradually

gradually till it becomes red hot, in which it must be continued during 24 hours. The heat must not melt the gold. The pot or crucible is then suffered to cool; and the gold carefully separated from the cement, and boiled at different times in a large quantity of pure water. It is then assayed upon a touchstone, or otherwise; and if it be not sufficiently pure, it is cemented a second time. In this process the vitriolic acid of the bricks, and of the calcined vitriol, decomposes the common salt during the cementation, by uniting to its alkaline base, while the marine acid becomes concentrated by the heat, and dissolves the silver alloyed with the gold. This is a very troublesome process, though it succeeds when the portion of silver is so small that it would be defended from the action of aqua fortis by the superabundant gold; but is little used, except to extract silver, or base metals, from the surface of gold, and thus giving to an alloyed metal, the colour and appearance of pure gold. And,

Thirdly, DRY PARTING. This process is performed by sulphur, which will easily unite with silver, but does not attack gold. As this dry parting is even troublesome, as well as expensive; it ought not to be undertaken but on a considerable quantity of silver alloyed with gold. The general procedure is as follows, viz. The metal must be granulated; from 1-8 to 1-5 of it, according as it is

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richer

richer or poorer in gold is reserved, and the rest well mingled with an eighth of powdered sulphur; and put into a crucible, keeping a gentle fire, that the silver before it melts, may be thoroughly penetrated by the sulphur; if the fire be hastily urged, the sulphur will be dissipated. If to sulphurated silver in fusion, pure silver be added, the latter falls to the bottom, and forms there a distinct fluid, not miscible with the other. The particles of gold having no affinity with the sulphurated silver, join themselves to the pure silver wherever they come in contact, and are thus transferred from the former into the latter, more or less perfectly, according as the pure silver was more or less thoroughly diffused through the mixed. It is for this use that a part of the granulated silver was reserved. The sulphurated mass being brought into fusion, and kept melting for near an hour in a covered crucible, one third of the reserved grains is thrown in, which, when melted, the whole is well stirred, that the fresh silver may be distributed through the mixed to collect the gold from it; this is performed with a wooden rod. This is repeated till the whole reserved metal be introduced. The sulphurated silver appears in fusion of a dark brown colour; after it has been kept in fusion for a certain time, a part of the sulphur having escaped from the top, the surface becomes white, and some bright drops of silver about the size of a pea, are perceived

perceived on it. When this happens the fire must be immediately discontinued, for otherwise more and more of the silver thus losing its sulphur, would subside and mingle with the part at the bottom, in which the gold is collected. The whole is poured into an iron mortar greased and duly heated. The gold diffused at first through the whole mass, is now found collected into a part of it at the bottom; amounting only to about as much as was reserved un-sulphurated. It is separated from the mass by a chisel or hammer; or more perfectly by placing the whole mass with its bottom upwards in a crucible; the sulphurated part quickly melts, leaving unmelted that which contains the gold. The sulphurated silver is assayed, by keeping a portion of it in fusion in an open crucible, till the sulphur is dissipated; and then dissolving it in aqua fortis. If it should still be found to contain gold, it must be subjected to the same treatment as before. The gold thus collected may be concentrated into a smaller part by repeating the whole process, so that at last it may be parted by aqua fortis without too much expence.

To purify Aqua Fortis.

IF the aqua fortis contain any vitriolic or marine acid, it may be separated by dropping into it a solution of silver in pure aqua fortis, till there be no

more precipitation in it. The remainder is very pure, and called precipitated aqua fortis.

To Assay the Value of Silver.

THE general method of examining the purity of silver, is by mixing it with a quantity of lead proportionate to the supposed portion of alloy; by testing this mixture, and afterwards weighing the remaining button of silver. This is the same process as refining silver by cupellation.

It is supposed that the mass of silver to be examined, consists of twelve equal parts, called penny-weights; so that if an ingot weigh an ounce, each of the parts will be $\frac{1}{12}$ of an ounce. Hence, if the mass of silver be pure, it is called silver of 12 penny-weights; if it contain $\frac{1}{12}$ of its weight of alloy, it is called silver of 11 penny weights; if $\frac{2}{12}$ of its weight be alloy, it is called silver of 10 penny-weights; which parts of pure silver are called fine penny-weights. It must be observed here, that assayers give the name penny-weight, to a weight equal to 24 real grains, which must not be confounded with their ideal weights; which is likely from their dividing their penny-weight into 24 grains like the real. The assayers grains are called fine grains. An ingot of fine silver, or silver of 12 penny-weights, contains then 288 fine grains; if this ingot contain $\frac{1}{288}$ of alloy, it is said to be silver of 11 penny

penny-weights and 23 grains; if it contain 4-238 of allay; it is said to be 11 penny-weights 20 grains, &c. Now a certain real weight must be taken to represent the assay-weights; for instance, 36 real grains represent 12 fine penny-weights; this is subdivided into a sufficient number of other smaller weights, which also represent fractions of fine penny-weights and grains. Thus 18 real grains represent six fine penny-weights; three real grains represent one fine penny-weight or 24 grains; a real grain and a half represent 12 fine grains; $\frac{1}{32}$ of a real grain represents a quarter of a fine grain, which is only $\frac{1}{752}$ part of a mass of 12 penny-weights. It is customary to make a double assay. The silver for the assay should be taken from opposite sides of the ingot, and tried on a touch-stone. Assayers know pretty nearly the value of silver merely by the look of the ingot, and still better by the test of the touchstone. The quantity of lead to be added is regulated by the portion of alloy, which being in general copper, it will be nearly as follows, viz.

Silver of		Dwts. Grs.		Dwts. Grs.		Requires from		Times its weight of lead.
From	11	6	—	—	—	—	5 to 6	
	10	12	—	—	—	—	8 — 9	
	9	18	to 9	0	—	—	12 — 13	
	8	6	— 7	12	—	—	13 — 14	
	6	18	— 6	0	—	—	14 — 15	
	3	0	— 1	12	—	—	0 — 16	
	1	12	— 0	18	—	—	0 — 20	

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The cupel must be heated red hot for half an hour before any metal is put upon it, by which all moisture is expelled. When the cupel is almost white by heat, the lead is put into it, and the fire encreased till the lead becomes red hot, smoaking, and is agitated by a motion of all its parts, called its circulation. Then the silver is to be put on the cupel, and the fire continued till the silver has entered the lead; and when the mass circulates well, the heat must be diminished by closing more or less the door of the assay furnace. The heat should be so regulated, that the metal on its surface appear convex and ardent, while the cupel is less red; that the smoke shall rise to the roof of the muffle, that undulations shall be made in all directions; and that the middle of the metal shall appear smooth, with a small circle of litharge, which is continually imbibed by the cupel. By this treatment the lead and alloy will be entirely absorbed by the cupel, and the silver become bright and shining, when it is said to lighten; after which, if the operation has been well performed, the silver will be covered with rainbow colours, which quickly undulate and cross each other, and then the button becomes fixed and solid.

The diminution of weight shews the quantity of alloy. As all lead contains a small portion of silver, an equal weight with that used in the assay, is tested off, and the product deducted from the assay-weight. This portion is called the witness.

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On P L A T I N A.

PLATINA is ranked among the perfect metals, because it is not destructable by fire. It is found in the gold Mines of Spanish America, in small angular grains; mixed with a species of black sand, which is attracted by the magnet, but neither soluble in acids, nor fusible. These grains resemble iron filings, but are somewhat whiter. It approaches near to gold in its specific gravity, and resembles that metal in being only soluble in aqua regia; from which like gold it may be separated by æther, alkalies, and by most metals. It may be precipitated from its solution in aqua regia by sal ammoniac, a property peculiar to this metal.

The attraction of platina to acids is nearly similar to that of gold; except that when precipitated from its solution, it is soluble in the acid of sugar, sorrel, lemons, ants, and of vinegar.

It differs essentially from gold, in being neither fusible nor malleable, unless combined with other metals by fusion; with some of which it readily unites, particularly with zinc. It has been fused by the blow-pipe with dephlogisticated air, and lately, in a furnace constructed on purpose by Mr. Willis of London.

On COPPER.

COPPER is an imperfect metal of a red shining color. Its specific gravity is 8.876. It is harder, more elastic, and sonorous, but a little less ductile than silver. It may be drawn into wire as fine as hair; one of which 1-10 of an inch in diameter, will support a weight of 299lb. four ounces without breaking. When rubbed in the hands, it exhales a disagreeable odor peculiar to itself; and has a taste not less unpleasant. When exposed to the fire with free access of air, it smokes, loses part of its weight, and communicates to flame beautiful green and blue colours. It resists more than any other of the imperfect metals, the action of fire, before it is altered; when a clean polished copper plate is exposed to heat, its surface is colored with all the colors of the rainbow; which proceeds from the development, and the different states of the phlogiston of the metal. When it is exposed to a red heat, its metallic lustre is changed into a dark earthy appearance; so that when it becomes cold, it separates in scales; which are called BURN'T COPPER. The combined action of air and water, produces a calcination of copper, which appears in the form of a greenish rust. The calx of copper urged with a violent fire is converted into a glass of a reddish brown color. This is called GLASS OF COPPER.

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The calx of copper highly dephlogisticated is reduced to a fine powder, and mixed with copal varnish; and then applied to the surface of valuable medals to preserve them from the action of the air; this is called BRONZING. All the acids dissolve copper. The solution in aqua regia is of a blue green color, in the vitriolic acid of a fine blue. If this last solution be evaporated, crystals are formed of a rhomboidal figure, which are called VITRIOL OF COPPER, BLUE VITRIOL, ROMAN VITRIOL, OR CYPRUS VITRIOL. The nitrous acid dissolves it with great facility, even when cold, and produces considerable heat and effervescence. This solution is of a fine blue color, not susceptible of crystallization, but forms a magma, which strongly attracts the moisture from the air, and is resolved into a liquor. The marine acid does not dissolve copper well, unless it be boiling; and then the solution is of a green hue. It yields crystals by evaporation. The acid of vinegar dissolves it, and the crystals formed by the solution are called VERDIGRISE. Fixed and volatile alkalies dissolve copper at least when it is in a calciform state; when dissolved by the last, it is called CUPRUM AMMONIACUM. If a mixture of copper filings and nitre be heated in a crucible together, the phlogiston of the copper unites with the nitrous acid, and leaves the calx of copper mixed with the alkali. Sulphur has a considerable action upon it; if copper plates be stratified

stratified with sulphur, and calcined; the sulphur attacks the copper, and converts it into an iron colored, very eager, and brittle matter. It is called *ENS VENERIS*, or copper calcined by *SULPHUR*.

Copper easily unites with all metals and semi-metals, and with them forms different compounds; of which, and its different precipitates, we shall speak hereafter.

L E A D.

LEAD is an imperfect metal of a white color, with a bluish tinge; darker than tin, the softest, least ductile, least elastic, and least sonorous of all the metals. It has a smell and taste peculiar to itself. Its specific gravity is 11.352, a leaden wire 1-10 of an inch diameter, is capable of supporting only 29lb. one quarter without breaking. It is very fusible and melts before it is red; and as soon as it melts, even with the least heat possible, it calcines. Nevertheless it resists much longer the combined action of air and water, than copper or iron, before it is decomposed or destroyed. The nitrous acid dissolves it readily, the solution is clear, limpid, and colourless; and being evaporated, yields a crystallizable salt, of a dead white, called *SATURNINE NITRE*. This salt
detonates

detonates when exposed to a sufficient degree of heat. The vitriolic acid does not dissolve it without heat, and then in small quantities. If in a solution of lead in nitrous acid, a little vitriolic acid be dropped, a white precipitate falls down, which is called VITRIOL OF LEAD. If the marine acid be added to the nitrous solution, a white precipitate in form of a coagulum is produced. This has the name of PLUMBUM CORNEUM. The acid of vinegar unites with it, and forms three different compounds, according to the proportion of acid combined. First, CERUSSE. To make which, leaden plates are rolled spirally, so that about the space of an inch shall be left between each circumvolution; and then suspended in an earthen pot containing good vinegar, but so as not to touch its surface. These pots are covered and placed in a bed of dung, or in a sand bath; by which a gentle heat is applied, and converts the acid into vapor, which attaches itself easily to these plates; penetrates them, and forms a white powder called cerusse. When a sufficient quantity of the powder is formed, the rolls are taken out of the pots, and unfolded. It is taken off, well washed and dried, and is sold under the name of WHITE LEAD. The lead is again rolled up, and the operation repeated. Secondly, This compound, which is insoluble in water, may be easily dissolved in a larger portion of vinegar; when it will shoot into crystals, and forms SACCHARUM SATURNI

SATURNI, or SUGAR OF LEAD; and thirdly, if vinegar be boiled with litharge (which is a calx of lead in a semi-vitrified state) it will become saturated, and forms GOULARD'S EXTRACT; which is decomposed by the addition of water; the white precipitate I consider as cerusse, and what remains dissolved in the water is a SACCHARUM SATURNI. All the vegetable acids dissolve lead; hence the necessity of caution in the use of leaden vessels for making of cyder wines, &c. and particularly in vessels for baking of fruit pies, which are in general glazed with lead, and most certainly are acted upon by the acid during the baking. It is a practice among wine dealers, whenever they have any wine which is called pricked, that is acid, to recover it by adding calx of lead, the acid is neutralized by its union with the lead; and acquires a sweetish taste. As the poisonous quality of this metal is well ascertained; it certainly is of importance to be able to discover whether wines contain it or not. The liver of sulphur is an excellent test. Add to the suspected wine, a little of the solution of liver of sulphur, and a precipitate immediately falls to the bottom. If it be of a fine yellow color, the liquor contains no lead; but if the precipitate contain lead, it will be from a dark brown to a black color, in proportion to the quantity holden in solution. The alkali of the hepar unites with the acid, and lets fall the sulphur, while the lead united with the acid precipitates

precipitates with it, if it contain any, and forms a dark brown or black powder. Lead easily combines with sulphur, and forms an artificial lead ore. It unites with all the metals except iron, and forms different compounds.

I R O N.

IRON is an imperfect metal, of a white, livid, greyish color. It is the hardest, the most elastic, and most difficult of fusion of all the metals, except platina. Its specific gravity is 7.80; an iron wire 1-10 of an inch diameter, is capable of sustaining a weight of 450lb. without breaking. Iron is very destructible. The combined action of air and water converts it into a rust; indeed, water alone, without the help of air, seems to be capable of acting upon it. Iron is not fused by the heat of ordinary furnaces, but it is easily burnt and calcined, by which it is changed into an earthy matter called CROCUS MARTIS, or SAFFRON of Mars. There are many species of iron; the celebrated Rinman divides them as follows: First, PERFECTLY MALLEABLE AND GOOD, or that which may be extended under the hammer; both cold and red hot, without contracting

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flaws,

flaws, or breaches at the corner; and which, with proper care, may be welded in a welding heat, without breaking or becoming brittle. Secondly, **HALF MALLEABLE**, or that which will bear gentle hammering only, but bursts in the corners from a stronger. The most remarkable varieties of this, are as follows, viz. First, **RED-SHORT**, or that which is tough and may be forged cold, and also in a white heat, but in a red heat cracks under the hammer. Secondly, **COLD-SHORT**, or that which may be forged in a strong red heat, but is brittle when cold. Thirdly, **UNMALLEABLE** and **CRUDE**, or that which cannot bear hammering either hot or cold, and approaches to the nature of crude or cast iron, which however is not meant here; and fourthly, **UNEQUAL**, or that which is soft and hard in the same bar, or which contains crude iron or grains of steel intermixed with its substance; iron of this last quality is termed *pinny*, by the workers in iron or steel.

The varieties of **MALLEABLE**, and **HALF-MALLEABLE IRON**, are almost innumerable, we shall mention such only as are known by certain denominations. First, **HARD IRON** may be perfectly malleable. In order to extend it, or beat it out, it requires only harder and a greater number of strokes with the hammer, and is either steel or mixed with steel. Of this there are several varieties. First, **HARD and STRONG**, which will bear forging and bend-

ing ; as, for instance, the iron of Danemōra, Öreg-rund, &c. in Sweden ; secondly, **HARD** and **BRITTLE**, or that which will bear hammering, but not bending, and is commonly mixed with steel ; thirdly, **HARD** and **TOUGH**, or that which will bear bending both hot and cold ; such is the best iron from Norberg ; and fourthly, **HARD** and **WILD**, or that which may be forged cold, or in a certain degree of heat, but breaks in a white and welding heat. **SOFT IRON**, which yields both hot and cold to the gentler force of the hammer and file. This may be first **SOFT** and **TOUGH**, which will bear much bending before it breaks. Of this kind is the **OSMUNDS**, and other sorts of Swedish iron ; secondly, **SOFT** and **BRITTLE**, or that which is easily forged while hot, and filed when cold ; but when handled roughly breaks with a shining surface, and consequently is of the cold-short kind ; and, thirdly, **SOFT** and **SPUNGY**, may be forged both hot and cold, into thin plates ; and likewise drawn out into wire, but easily breaks when bent with short fibres. This iron is produced chiefly from spongy, micaceous, hæmatitic ores, of a light grey colour. **TOUGH IRON**, or that which is perfectly malleable, and fit for all kinds of smith's work ; it may likewise be bent without heating, several times backward and forward before it breaks, in the form of bars or wire. It is either **TOUGH** and **SOFT**, or **TOUGH** and **HARD**, when it comes under the following head. **STIFF** and

STRONG IRON, which bears much bending, and wears well; at the same ~~same~~ time that it appears hard to the hammer and file. The smiths call it tough hard. It is not mixed with steel, and is used for making wire. CLOSE OR DENSE IRON, which is the opposite to soft and spongy. This must be of an equable texture through its whole mass; not burst in hammering, nor in polishing exhibit any stripes or spongy places, much less must it be what is called pinny; and at the same time it should be tough hard, or stiff and strong; in short, it must possess the properties of the best iron.

The best iron is that which first on being filed and polished, exhibits an equable light grey colour; secondly, that is the purest and densest, which possesses the greatest specific gravity. The toughness and strength of iron, however, cannot be discovered by this means. Thirdly, when two pieces of iron, similar in form, and equal in weight, are presented to a well armed magnet, that is the purest which holds the fastest; fourthly, it is longer in rusting in the open air, and when at last it does, it contracts a thin coat of rust, which is spread equably over its whole surface. Thus, for instance, a gun barrel which exhibits an equable brown rusty color in every part, consists of homogeneous iron. Fifthly, fire from the lowest to the highest degree of heat, is the most certain test of iron. Thus, that iron is esteemed the strongest,

strongest, which in the lowest degree of heat, or to speak more properly, in the cold, can bear to be most hammered when cold, and be bent the most without breaking. Iron which is the most expanded, or augmented in bulk, when exposed to heat, and consequently contracts the most in the cold, is the purest, for this reason, that the metal which requires the greatest heat for its fusion, is likewise subject to the greatest expansion and contraction. Now the purest iron, as experience shews, requires the greatest degree of heat for its fusion. If a bar of soft iron be welded with a piece of hard iron or steel, of an equal size, and cooled hastily while it is red hot; the mass becomes crooked, and bends towards the soft side, because this contracts most. The iron therefore which in cooling in water, is the least warped, is the most homogeneous and uniform. The harder the iron, the easier in general, it exhibits various colors on its surface, when exposed to heat, but particularly blue. Therefore, if iron acquires a blue color in different parts and places sooner than the whole does; this indicates a mixture of hard and soft iron; the soft parts do not turn blue, till this color begins to disappear on the hard parts. In a strong red heat the softest and toughest iron consumes and burns away most; it likewise produces the softest and least sharp scoriæ. In a strong welding or melting heat, the purest iron throws out white,

bright, crackling sparkles; which an experienced eye easily, and with certainty, distinguishes from the red, coarse, heavy sparkles of impure; and particularly red-short iron, and by this means can discriminate the iron itself. Pure iron likewise bears a stronger heat before it throws out sparkles, and in this case appears of a milky white colour. It also may then best be forged and united with other kinds of iron, that are subjected to an equal degree of heat. When prevented from coming into contact with the coals, the purest and most malleable iron does not fuse at all, or at least with more difficulty than any other sort. In its malleable state, therefore, it does not perfectly mix with any other metals; but when the air has access to it, together with combustible matter, the fusion becomes practicable. Pure common soft iron after being made red hot, becomes less hard by being extinguished in water, than when it has been left to cool in the air; it then bears hammering and bending; and is not found to be harder in one part than in another, by the file or hammer. Sixthly, aqua fortis and other corrosives shew a difference in iron. If it be laid in any of these an hour or two, soft and homogeneous iron appears of a silver white hue over its whole surface; the hard sort, of a dark grey color, and blackest; the mixed, variegated, dark, shadowy spots, generally indicate crude or cold short iron; and seventhly, in the cementation of
of

of steel, the properties of the iron appear extremely evident, and its defects plainer than before. Soft spongy iron of a foliated fracture, produces in the cementation of steel, blisters as large as walnuts; while dense and strong iron, of a finely granulated fracture, exhibits few blisters, or none on its surface. Red-short iron produces still a more red-short steel; and cold-short iron yields a steel so brittle, that it can neither be wrought hot nor cold. Flaws, fissures, and an uneven grain, are much more plain and distinct in cemented steel than in the iron. Soft iron produces still softer steel; and the Swedish iron of Oregrund and Dannemora, would hardly have been so well known in England, had it not had the trial of being cemented into steel.

For common purposes, a steel is prepared from a German iron, called Dort-square; the reason why it is so called, is, because it comes from a place called Dort, in square bars, of about 3-4 of an inch. The method of converting iron into steel by cementation, is as follows, viz. the iron is to be formed into bars of a convenient size, and then to be placed in a cementing furnace, with a sufficient quantity of cement, which is composed of coals of animal or vegetable substances, mixed with calcined bones, &c. The following are very excellent cements: first, one part of powdered charcoal, and half a part of wood ashes well mixed together; or, secondly, two parts of charcoal, moderately powdered, one part of bones,

horn, hair, or skins of animals, burnt in close vessels to blackness and powdered; and half a part of wood ashes, mix them well together. The bars of iron to be converted into steel, are placed upon a stratum of cement, and covered all over with the same; and the vessel which contains them closely luted, must be exposed to a red heat for eight or ten hours, when the iron will be converted into steel.

Steel is prepared from bar iron by fusion; which consists of plunging a bar into melted iron, and keeping it there for some time, by which process it is converted into good steel.

All iron which becomes harder by suddenly quenching in cold water is called steel; and that steel which in quenching acquires the greatest degree of hardness in the lowest degree of heat; and retains the greatest strength in and after induration, ought to be considered as the best.

The principal characters by which steel may be distinguished from iron, are as follows: First, After being furnished, steel appears of a whiter, light grey hue, without the blue cast exhibited by iron. It also takes a higher polish. Secondly, The hardest steel when not annealed, appears granulated, but dull, and without shining fibres. Thirdly, When steeped in acids the harder the steel is, of a darker grey hue is its surface. Fourthly, Steel is not so much inclined to rust as iron. Fifthly, In general, steel has a greater specific gravity. Sixthly, By being hardened

dened and wrought, it may be rendered much more elastic than iron. Seventhly, When indurated, it becomes more sonorous than iron. Eighthly, When furnished, it appears more close and dense than iron. Ninthly, It is not attracted so strongly by the magnet as soft iron is. It likewise acquires magnetic properties more slowly, but retains them longer; for which reason, steel is used in making needles for compasses, and for artificial magnets. Tenthly, By hammering and friction, it acquires a greater magnetic power than iron does. Eleventhly, In heat, steel expands more than iron. Twelfthly, By induration or quenching in water, it retains nearly the same bulk as it had acquired in heat, or at least contracts very little; while, on the other hand, iron contracts to the same space as it took up before ignition. Thirteenth, Steel is ignited sooner, and fuses with a less degree of heat, than malleable iron, which can scarcely be made to fuse without the addition of powdered charcoal; by which it is converted into steel, and afterwards into crude iron. Fourteenth, By a particular management, it may be fused and cast, and yet continue to be malleable; which is scarcely the case with soft iron. Fifteenth, Polished steel is sooner tinged by heat, and that with higher colors than iron. Sixteenth, In a calcining heat, it suffers less loss by burning, than soft iron does in the same heat, and the same time. In calcination a light blue flame

flame hovers over the steel, either with or without a sulphureous odor. Seventeenth, The scales of steel are harder and sharper than those of iron; and consequently more fit for polishing with. Eighteenth, In a white heat, when exposed to the blast of the bellows among the coals, it begins to sweat, wet, or melt, partly with light colored and bright, and partly with red sparkles, but less crackling than those of iron. In a melting heat too, it consumes faster. Nineteenth, By much welding, annealing, and hammering, in a slow, but strong heat; steel is converted into iron; cement steel sooner, and cast steel later. Twentieth, Covered with powdered charcoal, pressed down close upon it, and exposed to a strong heat, it acquires a slight coat, resembling black lead. By being frequently burned, it becomes as brittle as crude iron. Twenty-first, Digested with water in close vessels, it appears to yield a smaller quantity of inflammable air than iron. Twenty-second, Dissolved in vitriolic acid, it yields less inflammable air than soft iron does. Twenty-third, In the vitriolic, nitrous, and other acids, steel it is true is violently attacked, but is longer in dissolving than iron. After maceration, accordingly as it is softer or harder, it appears of a lighter, or darker grey color; while iron on the other hand is white. Twenty-fourth, In the solution of steel in acids, a smaller degree of heat is produced, than with tough, and still weaker, than with cold-short iron. Twenty-fifth,

fifth, It requires more nitrous acid for its compleat solution. Twenty-sixth, In the cold, it is proportionably harder and more brittle; or less malleable than pure iron. Twenty-seventh, In detonating with nitre, it yields more fixed air, than malleable iron does.

Steel differs from crude iron chiefly in malleability, a quality which is entirely wanting in the latter, both cold and hot; still, however, they both agree in many particulars, as for instance: First, Crude iron after being melted over again and polished, acquires as light and white a hue as steel. Secondly, They both acquire a variegated vitreous coat in the fire. Thirdly, Crude iron also becomes magnetic, though more slowly than steel. Fourthly, After being subjected to a red heat, it becomes harder by being extinguished in water, and particularly when melted, and immediately thrown into water. Fifthly, It melts easier than steel, and much easier than forged iron. Sixthly, When indurated, it strikes fire with flint, though the sparks produced by it are somewhat weaker than those generated by steel. Seventhly, Crude iron appears to yield as much inflammable air as steel by digestion in water. Eighthly, It likewise deposits a white sediment when macerated in acids. Ninthly, It rusts in the air as slowly as steel. Tenthly, When cast it rings like steel.

All

All the acids dissolve iron; the vitriolic requires to be diluted with water; when it acts with heat and effervescence. This liquor evaporated and left to crystallize, forms rhomboidal crystals, called MARTIAL VITRIOL, GREEN VITRIOL, OR GREEN COPPERAS. The nitrous acid dissolves it more actively and violently; the vapors during the solution, are red, very nauseous, and more volatile than those of the uncombined acid. Marine acid dissolves iron, but it does not so effectually deprive it of the inflammable principle as the nitrous. These two acids form with iron, neutral salts, very deliquescent. Aqua regia dissolves iron rapidly. When there is a super-abundant quantity of acid, the solutions of iron appear more or less green, and remain transparent; but when the acid is saturated with metal, the color is more or less yellow or reddish. Vegetable acids dissolve iron; the acid of tartar forms with this metal a very deliquescent salt, called TARTARISED MARS.

Alkalies and calcareous earth precipitate iron from its solution in acids; and when a solution of iron in nitrous acid, be dropped into good liquid alkali, a precipitate takes place, which on shaking the bottle is redissolved. This is called the MARTIAL ALKALINE TINCTURE OF STAHL. When this liquor is fully saturated with iron, and left to stand, a fine yellow brick colored powder is deposited, called SAF-
FRON

IRON OF STAHL. Sulphur has a particular affinity to iron. Iron unites with regulus of antimony, silver, copper, lead, &c.

On common hardening.

IRON by being heated red hot, and plunged into cold water, acquires a great degree of hardness. This proceeds from the coldness of the water, which contracts the particles of the iron into less space.

On Case-hardening.

CASE-HARDENING is a superficial conversion of iron into steel by cementation. It is performed on small pieces of iron; by inclosing them in an iron box, containing burnt leather, bone-dust, or any other phlogistic substance; and exposing them for some hours to a red heat. The surface of the iron attracts phlogiston, and becomes perfectly metallized. Iron thus treated is susceptible of the finest polish.

Of colouring Steel blue.

THE steel must be finely polished on its surface, and then exposed to an uniform degree of heat. Accordingly there are three ways of coloring; first, by a flame producing no foot, as spirits of wine; secondly, by a hot plate of iron; and thirdly, by wood-ashes. As a very regular degree of heat is

neceſſary, wood-aſhes for fine work bear the preference. The work muſt be covered over with them, and carefully watched; when the color is ſufficiently exalted, the work is perfect. This color is occaſionally taken off with a very dilute marine acid.

On plating of iron.

IRON may be plated by three different modes, viz. Firſt, by poliſhing the ſurface very clear and level with a burniſher; and afterwards by expoſing it to a bluing heat, a leaf of ſilver is properly placed and carefully burniſhed down. This is repeated till a ſufficient number of leaves is applied, to give the ſilver a proper body. Secondly, By the uſe of a folder. Slips of thin folder are placed between the iron and ſilver with a little flux, and ſecured together by binding wire. It is then placed in a clear fire, and continued in it till the folder melts; when it is taken out, and on cooling is found to adhere firmly; and thirdly, by tinning the iron firſt, and uniting the ſilver by the intermedia of thin ſlips of rolled tin, brought into fuſion in a gentle heat.

On TIN.

TIN is an imperfect metal, the color of which approaches to that of ſilver, but is ſomewhat darker,
and

and less white. It is very soft, malleable, and readily extensible under the hammer; and with little or no elasticity. Its specific gravity is 7.264. A wire 1-10 of an inch diameter, supports a weight of $49\frac{1}{2}$ lb. without breaking. When pure, it is scarcely sonorous; rubbed between the hands, it exhales a disagreeable odor peculiar to itself; and has a taste no less disagreeable. When bending it makes a crackling noise, as if it were breaking. It is very fusible, and requires a heat less than sufficient to make it red hot, to melt it; and when melted, its surface is covered with a whitish grey powder, which is called the CALX OF TIN: the calcination being continued, the calx acquires a white colour, and a good deal of hardness, and is then called PUTTY, which is used for polishing glass, steel, &c. If very pure tin be exposed to a strong heat, a part sublimes, in form of very white and brilliant needles, called FLOWERS OF TIN. The calx of tin urged with a very strong fire, enters into perfect fusion, and forms GLASS OF TIN, which is clear and transparent, and of a fine ruby or garnet color.

Leaves of Tin, or Tin-foil.

TIN is beaten into very fine thin squares, when it is called leaf-tin. These are used for tinning of looking-glasses.

The

The Method of tinning Looking Glasses.

THE success of this operation depends much on the cleanness of the glass; for the least dirt on its surface, will prevent the adhesion of contact between the tin and glass. The glass must be put on a table, in a perfect horizontal situation. The surface previously cleaned is to be covered with tin leaves, which also must be quite pure. Upon which is poured a sufficient quantity of quicksilver to cover the whole surface, where it remains, till a perfect amalgamation takes place; then a small degree of inclination is given it, that the superfluous quicksilver may run off.

The vitriolic acid dissolves tin with scarcely any effervescence, but requires the aid of heat. A strong smell of sulphureous acid exhales during the solution, and from the union of the acid with a portion of the phlogiston of the metal, a portion of sulphur is frequently formed. The NITROUS ACID does not so much dissolve as calcine tin. It attacks the metal with great violence, excites a very considerable degree of heat, and converts the metal into a very white calx insoluble in any acid. The MARINE ACID is the true solvent of tin, but it must be in a concentrated state, and aided by heat. This solution exhales a very strong odor of garlic and arsenic,

senic, and evaporated, yields crystals, which do not attract moisture from the air. They are called SAL JOVIS, or SALT OF TIN.

Aqua regia dissolves tin perfectly. This solution affords a great number of phenomena, sometimes it is colorless; in other circumstances of an amber color; sometimes of a dingy crimson, and sometimes it is converted into a fine white transparent gelly.

Tin causes nitre to deflagrate, and a brisk flame arises during the operation. The calx of tin remains with the alkali. Sulphur combines with it by fusion. The mixture is eager and brittle, and disposed in facets, like the broken surface of zinc.

If the crystals produced by the union of copper with nitrous acid, be triturated while they are in a moist state, and strewed upon tin foil to the thickness of the back part of the blade of a knife; then rolled up close, the extremities of the foil pinched together, and the whole mass pressed down close; great heat is produced, and at length follows a detonation, accompanied with flame.

On tinning Metals.

IRON which is to be tinned, must be previously steeped in acid materials, such as four whey, distiller's wash, &c. then scowered, and dipped in melted tin, having been first rubbed over with a solution of sal ammoniac. The surface of the tin is prevented from
L calcining

calcining, by covering it with a coat of fat. Copper vessels must be well cleansed; and then a sufficient quantity of tin with sal ammoniac is put therein, and brought into fusion, and the copper vessel moved about. A little resin is sometimes added. The sal ammoniac prevents the copper from scaling, and causes the tin to be fixed wherever it touches. Lately, zinc has been proposed for lining vessels instead of tin, to avoid the ill consequences which have been unjustly apprehended.

The most curious process in all the metallic arts, is, the tinning of copper and brass, by the following; boil, viz. six pounds of cream of tartar, four gallons of water, and eight pounds of grain tin, or tin shavings. After the materials have boiled a sufficient time, the substance to be tinned is put therein, and the boiling continued, when the tin is precipitated in its metallic form.

Professor Gadolin made a number of experiments to explain this phenomenon, from which the two principal conclusions, were, first, that copper cannot separate metalline tin from a solution in the tartareous acid, unless there be present a portion of tin in its metallic form; and secondly, that such a precipitate does not succeed, if the acid of tartar predominate to a certain degree.

The professor explains by observing, that the tin in the moment of solution, is in contact with another metal,

metal, viz. the copper, which has a strong attraction for the metallic tin; the attraction of the copper operates on one side, upon the metallic part of the dissolved tin, which is nearest the copper; and on the other hand, the other particles of dissolved tin, combine with that portion of the calcining matter (oxigène) which is nearest the copper; and by means of this separation of the calcining matter, the tin is deposited in its metallic form upon the copper; while the rest, the greatest part, undergoes a greater degree of calcination. This explanation appears to me very imperfect: First, Because the action of the menstruum on the copper is not noticed; and it seems as if the copper remained in a liquor capable of dissolving it, untouched; exerting only a simple attraction for the dissolved tin. Secondly, Bodies of equal affinity to the same menstruum, cannot decompose each other; consequently, the particles of tin cannot deprive each other of the oxigène, so as to precipitate metallic particles on the copper; and, thirdly, a superabundance of acid, ought not to prevent the Oxidation, but, on the contrary, as the acid must furnish the Oxigène, it ought rather to promote the process.

From some experiments which I have purposely made, I deduce the following rationale; viz. the acid of tartar, acts both on the surface of copper and tin; the phlogiston of the copper immediately on its extrication, is seized upon by those particles of tin,

which are precipitated by the attraction of the metallic copper, and hence assume their metallic splendor. Those particles of tin which come not within the sphere of such attraction, are diffused through the whole menstruum, which holding likewise a portion of copper in solution, forms a tartarized solution of tin and copper; in which state the metals have no action on each other.

Tin easily unites with all the metals.

B I S M U T H.

BISMUTH is also called TIN-GLASS. It is composed of cubes, formed by the application of plates upon each other. Its color is whitish, with a reddish tinge, after it has been exposed to the air. Its specific gravity is 9.670; it is very fusible, and melts a long time before it is red hot. When exposed to the fire it is calcined, and the flowers are sublimed; or it may be converted into a yellow glass, by urging the fire. This metal is not equally soluble in all the acids. The vitriolic assisted by heat corrodes it; the nitrous dissolves it perfectly, and the liquor evaporated and set by, crystallizes, and is called CRYSTALS OF BISMUTH. But if water be added to this solution, the bismuth will be precipitated

tated in a white powder, called MAGISTRY OF BISMUTH, OR SPANISH WHITE. The marine acid dissolves bismuth slowly, and with difficulty. All the alkalies precipitate it from its solution in the acids. It unites easily with sulphur in fusion; and with the different metals forming various compounds. This metal may be used for refining of silver by cupellation instead of lead.

If acid of tartar be added to the nitrous solution of this semi-metal, in the space of 15 minutes, pellucid crystalline grains are produced, which exhibit a TARTARIZED BISMUTH.

On NICKEL.

THE discovery of this metallic substance, was published by Mr. Cronstedt, a celebrated Swedish mineralogist, in the accounts of the academy of Stockholm, for the years 1751, and 1754. This mineral is found in several German mines, and probably in other countries, but very rarely. It is of a grey, and sometimes a shining yellowish color. It is to Arvidson, of Upsal, that we are indebted for a full analysis of this substance. He found that nickel is to water, as 9000 to 1000; that the more it was purified, the more it approached to the tenacity, mal-

leability, infusibility, and magnetism of iron; at the same time it becomes more fixed; more difficult to be calcined; and its calx is of a green color. It is soluble in acids. The vitriolic attacks its calx with which it forms a green salt, containing ten sides, called VITRIOL OF NICKEL. The acid of nitre dissolves it with difficulty. The marine, and most of the vegetable, dissolve it with more or less ease; and the solutions are more or less inclined to a green color. Alkalies combine with it. The solution made with fixed alkalies is yellowish; while that of the volatile alkali is always blue. Although it is as difficult of fusion as forged iron when purified; it easily fuses, when combined with other metals. Impure nickel will not contract any union with silver; and copper unites with difficulty; it will not amalgamate with quicksilver; but when pure it melts with zinc, and forms a brittle alloy.

Nickel is not at present used in the ARTS. It tinges glass of a green color.

A R S E N I C.

ARSENIC is the calx of a semi-metal; of a white, crystalline, brilliant mass; but soon becoming opaque, without losing its whiteness. Weighed in

in water it loses 1-5 of its weight. It has some properties in common with salts. It dissolves in oily, spirituous, and watery liquors. It unites with phlogiston, and is changed into a true semi-metal, which is called **REGULUS OF ARSENIC**. This is heavier than arsenic; its specific gravity is 8.308. Arsenic differs essentially from all metallic calces and earths; first, in being constantly volatile; secondly, metallic calces when perfectly calcined, are entirely free from taste, smell, &c. thirdly, no kind of earths, nor metallic calces, can contract an union with metallic substances; arsenic will unite with all the metals and semi-metals; and fourthly, earths and metallic calces have not any action on nitre; whereas arsenic decomposes it, not by destroying its acid, as phlogiston does, but by disengaging it, and uniting with its alkaline base, forming **NEUTRAL ARSENICAL SALT**. The mineral acids attack arsenic, but make a bad solution. Sulphur unites with it, and forms a semi-transparent, very heavy mass of a yellow color, called **ORPIMENT**; if the portion of sulphur be augmented, there results a red, shining, brittle substance, called **RED ORPIMENT**, or **REALGAR**. It has been amalgamated with quicksilver, but this union is attended with great difficulty.

ANTIMONY.

THIS is a mineral, of a metallic shining leaden color; composed of long, brittle, parallel needles. It is composed of a semi-metallic substance, called REGULUS AND SULPHUR. The specific gravity of the regulus is 6.860. The regulus is obtained, by putting the crude ore in a crucible with charcoal dust, and a quantity of iron nails, and when it is in fusion, projecting now and then a little nitre. It is then poured into a cone, and the regulus will be found at the bottom. This is moderately hard, but possesses no ductility; the action of air and water destroys its lustre. It is fusible in a moderate heat, which being encreased, it is dissipated in vapors, which are called the ARGENTINE FLOWERS of the REGULUS of ANTIMONY. The regulus, by a calcination in a moderate fire, is changed into a grey calx, which being urged with a greater heat, is converted into a transparent glass, called GLASS of ANTIMONY, of a brown color, more or less deep. The mineral acids dissolve regulus of antimony with great difficulty; to dissolve it in the vitriolic, the acid must be applied in a very concentrated state, and exposed to a considerable degree of heat. A very volatile sulphureous acid arises, of a very penetrating smell, and at the bottom of the vessel, remains a white saline

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line mass. The nitrous acid only corrodes the regulus, and converts it into a white calx. The marine acid acts upon regulus, by particular treatment, and forms a compound, called BUTTER of ANTIMONY.

To make Butter of Antimony.

TO six ounces of well pulverised regulus of antimony, add 16 ounces of corrosive sublimate. Distil with a gentle heat, in a sand bath; after having luted a receiver to the retort. The fire is to be gradually encreased, and a heavy liquor arises, which congeals in the receiver as it cools. This is the butter. In this process, the acid of the corrosive sublimate becomes very concentrated, and by the heat attacks the antimony, and is converted into a liquor which condenses in cold; the mercury of the corrosive sublimate is left behind in a fluid state. If any running mercury should be forced over by the heat being too great during the distillation, it is purified therefrom by a second distillation, which is called RECTIFICATION. If water be added to butter of antimony, a white powder precipitates, which is called POWDER of ALGAROTH. This powder dissolved in acid of tartar, forms the emetic tartar, which, when properly prepared, so that equal quantities shall always contain equal portions of antimony, is vastly superior to Dr. James's powder, or
all

all the other antimonial preparations. Bergman from an analysis of an ounce of different emetic tartars, found one to contain 90 grains, another 108 grains, and a third 154 grains of antimony; and this variation will generally be found in this article, procured for common sale. The following is a process, by which emetic tartar is obtained, that invariably contains a precise quantity of antimony, viz. boil five ounces of cream of tartar, with two and a half drachms of powder of algaroth, in a sufficient quantity of distilled water in a glass vessel. The powder of algaroth must be previously well washed. This solution being gently evaporated yields crystals, which must be put on paper unalumed, to absorb the super-abundant moisture. These crystals contain 1-3 of their weight of antimony; and three grains may be dissolved in half an ounce of pure water.

Liver of Antimony.

AFTER the detonation of equal parts of nitre and crude antimony, the matter enters into fusion, and on breaking the crucible, there is found at the bottom, a brown, opaque, very brilliant mass, which easily breaks, and is called LIVER of ANTIMONY.

Rotrou's Solvent.

CRUDE antimony, with three parts nitre, becomes dephlogisticated by the action of the fire and nitre.

nitre. The residuum enters into a paste like fusion; it is poured on a marble, pulverised and kept in a bottle.

The mass remaining above is white and opaque. It attracts moisture from the air. The salts which it contains dissolve in water, and a white powder falls down, which bears the name of DIAPHORETIC ANTIMONY; which is the same as the MATERIA PERLATA, or CERUSS of ANTIMONY.

Aqua regia dissolves the regulus of antimony, with the assistance of heat; if crude antimony be used the sulphur is separated of its usual color.

Butter of animony is dissolved both in the marine and nitrous acids; if the last solution be evaporated to dryness, a white powder remains, called BEZOAR MINERAL.

Alkalies act on crude antimony, either in the dry or moist way. If alkaline salt and crude antimony be fused together, the alkali unites with the sulphur, and forms a hepar, which dissolves a portion of the regulus. It forms a mass of a deep red color, soluble in boiling water; which when cold deposits a red powder, called KERMES'S MINERAL. The best method of preparing Kermes, is, by reducing crude antimony to a fine powder, and throwing it in small quantities into a boiling alkaline liquor. The Kermes forms in a minute, the liquor must be filtered;

tered; and the process repeated till no more is formed.

The regulus of antimony unites with most of the metals, and forms different compounds.

COBALT.

COBALT is a very heavy metal, of no determinate figure; of a grey color, more or less brilliant; of a fine compact close grain; the surface of which, when it has been exposed to the air, is covered with an efflorescence of the color of a peach blossom. Its specific gravity is 7.700. This regulus is extracted from an ore, which likewise affords arsenic; and sometimes silver and bismuth. The torrefied ore reduced to powder, and mixed with twice its weight of flints forms ZAFFRE. Zaffre mixed with fixed alkali, and brought into a glassy fusion, forms AZURE BLUE.

The regulus becomes red in the fire before it melts. The vitriolic acid dissolves it with difficulty, and then must be assisted by heat. The solution is of a deep reddish color. The nitrous acid dissolves it with impetuosity; the solution is of a dingy crimson color; and if evaporated yields crystals, called

COBAL TIC

COBALTIC NITRE. The marine acid will dissolve it, but it must be cohobated several times. The best solvent is aqua regia; its solution is clear, and of a peach blossom color.

It is precipitated from its solutions by the alkalis.

On MANGANESE.

THIS semi-metal was first accurately described; and its properties admirably explained by the celebrated Scheele, about the year 1774. It was afterwards exhibited in its metallic form by Mr. Gahn, of Upsal, and described by Bergman, in the 2nd vol. of his works; since which it has been produced by several chemists in every part of Europe.

The regulus is of a dusky white color, an irregular and uneven surface, arising from its imperfect fusion; in its fracture, it is bright and shining, but soon tarnishes on exposure to the air. It is harder than iron, less fusible, and very brittle. Its specific gravity is 6.850. When pulverised it is always magnetic, though larger pieces be not so. If it be exposed to the air, particularly in moist weather, it soon crumbles into a blackish brown powder, which is sometimes heavier than the regulus. It is soluble
in

in acids, but most readily in the nitrous, and its solutions are mostly of a reddish color, but that in the nitrous is generally brownish from a slight taint of iron; but there is always a spongy residuum of the nature of plumbago left undissolved. These solutions give a white precipitate, which on exposure to heat grows black. Manganese fused with fixed alkali, yields a dark green mass, which dissolves also with the same color in water; but from this changes to red.

It is used in glass-houses to render green glass white. It is probable that glass is colored by the phlogiston, contained in the impure flints, or alkali used in forming the glass. The calx of manganese has a very strong attraction for phlogiston; consequently, by adding it, it deprives the glass of its super-abundant quantity, and by communicating a darkish tinge, destroys the remaining bluish cast, and produces an apparent whiteness.

The MINERAL CAMELEON.

IF one part of manganese, be mixed with three parts of nitre, and kept in a crucible in the fire, till the nitre be destroyed, the mixture becomes a grumous mass, and is called the MINERAL CAMELEON, because

because if a little of it be poured into a glass of spring water, the finest change of colors is seen in the quickest succession; a most beautiful green color appearing first, which is instantly changed to a violet, and lastly to a red.

ZINC, *or* SPELTER.

ZINC is a semi-metal of a whitish color, rather of a bluish cast; very malleable, and capable of being beaten into very thin plates. Its specific gravity is 6.862. It is not easily calcined by the action of air and water. It enters into fusion at the same time that it becomes red. Continued in this heat, its surface is calcined and reduced to a grey calx; but when it is exposed to a white heat, it flames, and during the inflammation, it exhibits a very beautiful and striking appearance. The flame of zinc is infinitely more lively, more luminous and brilliant than the flame of any other inflammable body. During this combustion, the calx is raised in vapor, which being condensed forms light flocks; these are called FLOWERS of ZINC, or PHILOSOPHICAL WOOL. The acids dissolve zinc; the vitriolic with considerable effervescence; the solution evaporated yields crystals, called VITRIOL of ZINC, or WHITE COPPERAS.

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The nitrous and marine dissolve it, the former solution crystallizes into a foliated saline lump, which attracts moisture from the air; the latter does not crystallize, it yields inflammable air during its solution; and deposits black flakes, which appear to be plumbago. Sulphur has not any action upon it, hence a complete method of separating any other metal from it. It unites with most of the metals, and forms different alloys.

As much of the METALLIC NATURE of MOLYBDENA and TUNGSTEN as is known, has been mentioned before.

QUICKSILVER.

QUICKSILVER is a shining metallic substance, resembling silver externally. Its specific gravity is 14.110 a cubic foot weighs 947lb. neither air nor water, has any action upon it, but by particular treatment. Its surface tarnishes nevertheless to a certain degree, and more quickly than gold or silver, when it is exposed to the air, but this proceeds from the dust floating in the air fixing on its surface; watery vapors also appear to be attracted by mercury. It is easily purified from any adhering substance, by pressing it through leather. Its inte-

grant parts like fluids mutually attract each other, and always acquire a convex or spherical form, when they touch bodies with which they have no tendency to unite. Mercury exposed to the fire suffers no change from a heat which is not superior to boiling water. In a great heat it is entirely evaporated away; and it undergoes no change from this evaporation; for if the vapors be condensed, they will form running mercury again. Boerhaave distilled 18 ounces of quicksilver 500 times, without perceiving any other change, than that its fluidity and specific gravity were a little encreased, probably from a purification of the mercury, rather than from any change in its parts. By digesting mercury in a strong heat, it is calcined on its surface; forming a red powder called PRECIPITATE PER SE. The strongest heat which mercury can sustain is necessary for this preparation. Till lately, it was thought, that the fluidity of mercury, was as essential to it in its natural state as its volatility; so that those, who had labored to render it fixed, expected to attain their purpose only, by producing a great change on its nature. In 1759, quicksilver was consolidated by some of the Members of the Academy of Petersburg. On the 25th of December, in that year the cold was intense; which assisted by artificial methods, perfectly congealed the Quicksilver. This has been effected frequently since by artificial means only, by Mr.

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Walker,

Walker, of Oxford. In this state of congelation it bore to be extended under the hammer, but did not remain solid longer than a few minutes.

Vitriolic acid does not dissolve mercury, or but a small portion of it; the saline crystalline mass left after the action of the vitriol, is called VITRIOL OF MERCURY, which being diffused in a large quantity of water, gives a fine bright yellow precipitate, called YELLOW PRECIPITATE, or TURBITH MINERAL. During the washing of the vitriol of mercury, the water dissolves a portion of it; and if an alkali be added, a yellow precipitate falls down, of the same nature, but something paler than the above. The nitrous acid dissolves mercury with heat and effervescence. The solution is almost colorless; evaporated it yields crystals, called MERCURIAL NITRE; which, by being exposed to heat, loses almost all its acid, and becomes of a red color, and is called RED PRECIPITATE. The marine acid dissolves quicksilver in small quantity when concentrated and assisted by heat. If to a solution of quicksilver in nitrous acid a little marine acid be added, a white precipitate of little solubility falls down, called WHITE PRECIPITATE; which being dissolved in dilute marine acid, and evaporated, yields crystals of CORROSIVE SUBLIMATE. This method is more convenient, and more simple than the common method of making corrosive sublimate, which is as follows, viz. take quicksilver four
ounces,

ounces, and dissolve it in four ounces of weak nitrous acid, evaporate the solution to dryness; then add sea salt, and martial vitriol, of each five ounces, grind them well together and sublime. This salt contains a super-abundant quantity of acid, which being neutralized by triturating it with quicksilver and sublimed, is called CALOMEL. Vinegar dissolves the calx of mercury, and forms flaky crystals. Most of the vegetable acids act upon its calx.

Sulphur unites with quicksilver; if they be sublimed together, a reddish mass is produced, called CINNABAR, which being finely ground, acquires a fine scarlet color, and is called VERMILLION. By being triturated together, they form a black powder, called ÆTHIOPS MINERAL.

The alkalis precipitate it from its solution in the acids, and if they be in a caustic state, redissolve a portion of the calx.

Quicksilver may be reduced to a calciform state by agitation. Homberg first made the experiment, by tying a vessel containing a quantity of it to the wing of a windmill.

On COMPOUND METALS.

METALS in general will unite with each other by fusion or amalgamation, and acquire new properties. Brass is a compound of copper and zinc;

M 2

and

and possesses a different color to either of the component parts. Sometimes the compound will retain the color of one of the component metals, particularly when there is a great difference in the proportion of the parts, as in the amalgamation of gold with quicksilver. Compound metals are always of greater specific gravity than either of their parts, but their absolute gravity is diminished. Their ductility and malleability differ from the metals which compose them, sometimes encreasing, at others diminishing. Silver and tin in an uncombined state are both malleable and ductile; but silver united to a small portion of tin, has them both diminished. The volatility of metals is much affected by union; the most fixed becoming volatile, whilst the most volatile acquires a certain degree of fixity. Gold, though very fixed in itself, yet can be elevated by heat when amalgamated; while the mercury by the union loses considerably of its volatility. Their fusibility is much altered by mixture; a remarkable instance occurs in the compound of Bismuth, tin, and lead. Eight parts of bismuth, three of tin, and five of lead, will form a metal, which will completely melt in boiling water; which is a degree of heat less by 193° than the most fusible metal of the compound, viz. Tin.

Bell-metal is a striking proof of the change which the properties of bodies undergo from union. This compound is one of the hardest and most sonorous
of

of all the compound metals, although copper is very little sonorous, and tin less so.

Standard of British Gold Coin.

THIS standard by law, is for every pound troy weight, to contain 11-12 of pure gold, and 1-12 of alloy. This quantity is cut into forty-four guineas and a half, or other pieces of like nominal value, without any deduction.

Standard Silver.

ELEVEN ounces two penny-weights of fine silver, and eighteen penny-weights of alloy in a pound troy.

Gold Solder.

PURE gold twelve penny-weights ; pure silver two penny-weights, and copper four penny-weights.

Ring-Gold.

SPANISH copper six penny-weights and twelve grains ; three penny-weights and sixteen grains of fine silver ; to one ounce five penny-weights of gold coin. This is worth about 3l. per ounce.

Gold from 35s. to 40s. per Ounce.

EIGHT ounces eight penny-weights of Spanish copper, ten penny-weights of fine silver, to one ounce of gold coin.

Manheim-Gold, or Similor.

THREE ounces and a half of copper, one ounce and a half of brass, and fifteen grains of pure tin.

Pinchbeck.

ONE ounce of brass, one ounce and a half, or two ounces of copper fused together, under a coat of charcoal dust.

Prince's Metal.

Three ounces of copper, and one ounce of zinc, or eight ounces of brass, and one ounce of zinc.

Tombac.

SIXTEEN ounces of copper, one ounce of tin, and one ounce of zinc.

Hard Pewter.

TWELVE ounces of tin, one ounce of regulus of antimony, and two drachms of copper.

Blanched Copper.

EIGHT ounces of copper, and half an ounce of neutral arsenical salt, fused together, under a flux composed of calcined borax, charcoal dust, and fine powder glass.

Bell Metal.

ONE hundred parts of copper, mixed with from twenty to twenty-five parts of tin.

Gun Metal.

ONE hundred pounds of copper, and twelve pounds of tin, either with or without a little brass.

Best hard White.

ONE pound of Bristol brass, two ounces of spelter, and one ounce of block tin.

Common hard White.

ONE pound of brass, one ounce and a half of spelter, and half an ounce of tin.

Bath Metal.

ONE pound of brass, and four ounces and a half of spelter.

White Metal.

TWO pounds of regulus of antimony, eight ounces of brass, and ten ounces of tin.

Platina.

EIGHT ounces of brass, and five ounces of spelter.

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Tutania

Tutania.

EIGHT ounces of brass, two pounds of regulus of antimony, and seven ounces of tin.

Silver Solder for Jewellers.

NINETEEN penny-weights of fine silver, copper one penny-weight, and of brass ten penny-weights.

Silver Solder for plating.

TEN penny-weights of brass, and one ounce of pure silver.

A metallic Injection.

EQUAL parts of bismuth, lead, and Tin, with a sufficient quantity of quicksilver, form a substance useful for injecting the blood vessels of animals.

For quicking hollow Globes, &c.

TWO parts of bismuth, one of tin and lead, and ten of mercury, mixed together, form the amalgam, which is spread by giving the globe a circular motion.

Tutenag.

TWO parts of tin, and one of bismuth.

A Metal for Printer's Types.

DIFFERENT proportions of lead, copper, brass, and antimony, constitute this metal. Every
artist

artist has his own proportions, so that the same composition cannot be obtained from different founderies; each boasts of the superiority of his own mixture.

Hard Solder.

TWO pounds of copper, to one pound of tin.

Soft Solder.

TWO thirds of tin, and one of lead.

A white Copper.

THIRTY-TWO parts of copper, fifteen of tin, four of brass, and two of arsenic.

A white Metal.

TEN ounces of lead, six ounces of bisinuth, and four drachms of regulus of antimony.

A Metal for Mirrors.

COPPER thirty-two parts, tin fifteen, brass one, silver one, arsenic one.

Brass.

BRASS is either made by fusing copper and zinc together; or by fusing copper and the ore of zinc, or lapis calaminaris. From 60lb. of good calamine, and 40lb. of copper, 60lb. of brass may be obtained. To obtain a better brass either the metals must be used, or the common brass must be cemented with calamine

calamine and charcoal dust, and sometimes manufacturers add to it, old brass, by which the new is said to be meliorated.

On the FORMATION *of* COMPOUND METALS.

THE attraction of cohesion of the different metals, which are to form the compound, must be overcome; accordingly they are brought into a state of fusion, and well mixed together. The compound is not formed by a chemical union of the particles of the different metals, but from an equable diffusion through each other, and, being detained in that state by the attraction of cohesion. As metals fuse in different degrees of heat, care should be taken not to add those metals which fuse easily, to those which require a greater degree of heat, while they are too hot; because the former may evaporate and leave the compound imperfect. Or, if they be brought into fusion together, it should be under a flux to prevent the volatile metals from being burnt away, before the union is effected.

PART III.

ON

METALLIC CALCES

AND

PRECIPITATES.



On METALLIC CALCES and PRECIPITATES.

FIRST, By metallic calces, we understand metals simply deprived of their phlogiston by the action of heat and air.

Secondly, By precipitate, that insoluble substance which is thrown down, after the solution of a metal in an acid, on the application of a simple or compound body, which exerts a greater attraction for the solvent.

METALLIC CALCES and PRECIPITATES of GOLD.

A solution of gold in aqua regia, which is evaporated to dryness, leaves a calx of gold which is used for glass, enamel, and porcelain gilding; or by precipitating the solution with green vitriol dissolved in water, with copper, or perhaps all the metals, a similar calx is produced. This calx is mixed with some essential oil, as oil of spike, and calcined borax, and the whole made to adhere to the surface of the glass, by a solution of gum arabic. It is then applied with a fine pencil, and burnt in under a muffle.

Mineral purple, or Cassius's Precipitate.

M A K E a solution of gold in aqua regia. Then make another solution of tin in the same menstruum; without heat, by adding the tin in small quantities, till it is saturated; which may be known by the aqua regia acting no longer on the tin; and the solution acquiring a brownish whey color. The solution of gold is to be diluted with 100 times its quantity of distilled water; and to this is added the solution of tin, drop by drop, till the liquor ceases to become turbid. The precipitate is of a purple color, and must beedulcorated. The gold is precipitated by the tin, merely from their intimate affinity to each other.

This calx of gold brought into fusion with a clear transparent glass, tinges it of a purple, red, or violet color. Hence the method of making false rubies and garnets.

Glass melted with a highly dephlogisticated calx of gold, retains its transparency; but on the application of heat, it absorbs phlogiston, and produces a fine crimson color.

A solution of gold in aqua regia, applied to bone or ivory, leaves a reddish purple stain, which does not wear out. Skins are stained in the same manner.

If writing be made with a dilute solution of gold in aqua regia; and when dry brushed over with a solution

lution of tin in aqua regia; the letters will appear of a fine purple color. This is a SYMPATHETIC INK.

There is no precipitate of silver used in the arts; a solution of silver in nitrous acid is applied for staining animal matters of a black color, and the calx will tinge glass yellow.

On the CALCES *and* PRECIPITATES *of* COPPER.

THE simple calx of copper fused with glass, tinges it of a green color, hence the imitation of emeralds.

A green Color.

IF a solution be made of common salt and blue vitriol in water, by putting copper plates therein, a green precipitate is gradually formed.

Scheele's green Color.

DISSOLVE two pounds of blue vitriol in six pounds of water, in a copper vessel; and in another vessel, dissolve two pounds of dry white pot-ash, and eleven ounces of white arsenic, in two pounds of water. When the solutions are perfect, pour the arsenical ley into the other gradually, and you will obtain about one pound six ounces of a good green precipitate.

Brunswick

Brunswick green.

THIS is supposed to be obtained from the solution of a precipitate of copper in tartar and water, which by evaporation yields a transparent cupreous tartar, which is said to be similar to the superfine Brunswick green.

Verditer.

THE method of preparing this color, is kept a profound secret. The general method of procedure is as follows: but the success of the process, depends entirely upon circumstances; which can only be known from great attention, and some experience. The liquor which is used in parting, is fully saturated with silver; which is precipitated by adding very pure copper. This nitrous solution of copper must be properly diluted with very pure water, distilled is the best, and the copper precipitated on chalk properly prepared. The color and chalk must be well mixed together and properly dried.

If some copper filings be put into a bottle with caustic volatile alkali, so that no empty space remains, and then closely stopped, no solution takes place. But when the mixture is exposed to the air for a short time; a colorless solution is obtained; which on longer exposure, acquires a blue color; but which may be deprived of this color again, as
often

often as the operator pleases, by letting it stand closely stopped, upon fresh copper filings.

On the CALCES *and* PRECIPITATES *of* LEAD.

LEAD exposed to the action of fire and air calcines; this calx is called LEAD ASHES. By the calcination being continued longer, it acquires a yellow color, and is called MASSICOT; and by a brisker and longer continued heat, MINIUM, or red lead is produced. A greater degree of heat converts the calx of lead, first into LITHARGE, and afterwards into GLASS of LEAD.

The operation of making red lead, is as follows, viz. a quantity of lead is fused upon a hearth, and worked about with an iron rod, till the calx acquires a yellow color. Then it is ground small with water at a mill, constructed for the purpose; and well washed to deprive it of small lumps, which may remain uncalcined. This massicot, well dried is put into stone pots, which are placed horizontally in the color furnace. These pots are something more than a quarter full, and applied to heat till they acquire a red color; a brick is placed at the mouth of each pot to confine the heat; but is removed occasionally to work the matter about. By continuing this heat a

N

sufficient

sufficient time, the color becomes finer and finer till the minium is perfect.

PATENT YELLOW.

ALTHOUGH a patent is obtained for this color, it was known near a century ago; Scheele published the process, and is said to be the inventor. It is prepared by triturating MINIMUM, and common salt together, and then exposing them in a crucible to a gentle heat. In this process, the salt is decomposed, the acid uniting with the calx of lead, forms the PATENT YELLOW, and the alkaline base of the salt remains in the compound; which is obtained by carefully washing and crystallizing.

The calx of lead tinges vitreous matters of a yellow color. Hence the beautiful glazing given to Queen's Ware. It is composed of 80lb. of white lead, and 20lb. of flints, ground together very fine, and mixed with water till it becomes as thick as cream. The vessels to be glazed, are dipped into the glaze, and suffered to dry; when they are exposed to a sufficient degree of heat to vitrify the surface.

A SYMPATHETIC INK is formed, by making a solution of sugar of lead in pure water; the writing with this solution appears, upon the application of a solution

solution of liver of sulphur in water, or, by being holden over the vapor of a liver of sulphur.

On the CALCES *and* PRECIPITATES *of* IRON.

THE calces of iron are of different colors, as red, yellow, and brown. They are used as pigments under the name of ochres. The red, or astringent saffron of iron, is used for giving tea-urns their beautiful red brown color. When fused with glass they give red, or aurora colors, more or less deep, according to the degree of calcination. These imitate the HYACINTHS.

The calx of copper dissolved in vitriolic acid is recovered in a metallic form, on the application of iron to the solution.

On PRUSSIAN BLUE.

PREVIOUS to the making of this substance, an alkali must be prepared as follows, viz. fixed alkali must be burnt in ox's blood, or with horn shavings, or any other animal matter. The salt is now to be washed out, and is called, though improperly, LYE

of PHLOGISTICATED ALKALI, which is of an amber color, and has the scent of peach blossoms.

A solution of martial vitriol, and another of alum, are put together in a large glass, and the alkaline lye poured upon them. A greenish precipitate is thrown down. The liquor is filtered in order to get the precipitate by itself, which is collected and put into a glass cup. Upon pouring a little marine acid on this precipitate, it immediately acquires a fine blue color. This part of the process, is called the brightening of the Prussian blue.

Theory of Prussian Blue.

THE alkali during the calcination, unites itself with a peculiar acid, contained in the animal matters. During the formation of the Prussian blue the following changes take place. First, A part of the uncombined alkali, precipitates the earth of alum; secondly, a part of the same alkali, precipitates a portion of the iron in the vitriol; and, thirdly, the Prussian acid unites with the remaining iron, and forms Prussian blue. This is of a greenish color, from the mixtures of the first and second precipitates; the brightening is produced by the marine acid, dissolving the calx of the second precipitate.

Prussian blue may be made without alum, in the following manner. Pour a little of the alkaline lye into a glass, drop in an acid, till no farther effervescence

cence ensues. Let a little of the solution of martial vitriol be poured into the lye, and a fine Prussian blue is formed that needs no brightening.

The common stone blues, are Prussian blue, precipitated on large quantities of clay.

SYMPATHETIC INKS of IRON.

FIRST, If writing be made with a solution of green vitriol in water, to which a little acid has been added, to prevent any precipitation, and when dry, it be brushed over with a strong decoction of galls, the invisible characters will be rendered of a fine black color.

Secondly, If the characters written with ordinary ink, be destroyed by nitrous acid, it is recovered by moistening them with liquid fixed alkali.

Thirdly, Characters written with a solution of green vitriol, will appear of a fine blue color, if they be moistened with some of the prussianated alkaline lye.

If a small quantity of dilute nitrous acid be put upon a piece of glass, and a rusty nail put therein, fine ramifications spread about, which may be burnt in, and give the appearance of mocoës.

C A L X of T I N.

THE calx of tin is principally used for making white enamel, an instance of such composition is as follows, viz. ten parts of sand, two of purified alkali, ten of the calx of lead, and three of the calx of tin, mixed together, and brought into fusion. If the enamel be wanted of any other color, it is produced by adding different metallic calces, *ad libitum*.

Opaque natural stones, may be imitated by the different colored enamels.

Aurum Musivum.

FUSE twelve ounces of tin, and add to it three ounces of Mercury. When it is cold, it must be triturated with seven ounces of sulphur, and three of sal ammoniac. The mass is put into a matrafs rather deep in sand, with a gentle heat for several hours; at length the heat must be encreased for several hours longer. The tin is developed by the marine acid of the sal ammoniac, and upon this combines with a portion of the sulphur; the remaining sulphur, sal ammoniac, and mercury, are sublimed; at the bottom of the matrafs, the tin is found of a gold colored micaceous appearance, throughout its whole substance. If the heat be too strong, the aurum musivum, fuses into a black mass.

CALX

CALX of ANTIMONY. *Naples Yellow.*

THERE are two processes given for making this color. First, one pound of antimony, one pound and a half of lead, one ounce of alum, and one ounce of common salt. Secondly, twelve ounces of pure cerufs, two ounces of diaphoretic antimony, half an ounce of calcined alum, and one ounce of pure sal ammoniac. The ingredients are to be well mixed together, and calcined in a moderate heat for three hours, in a covered crucible, till it becomes barely red hot; when the mass will become of a beautiful yellow color. With a larger portion of calx of antimony, and sal ammoniac, the yellow verges towards gold color.

Glass may be tinged yellow with the above preparation.

On the CALX of COBALT.

WHEN regulus of cobalt is exposed to a moderate fire in the open air, it calcines, and is reduced to a blackish powder.

This calx vitrifies with vitrifiable matters, and forms beautiful blue glasses. Cobalt is at present the only substance known, which has the property

of furnishing a very fine blue, that is not changed by the most intense heat.

Sympathetic Ink of Cobalt.

DIGEST zaffre in aqua regia, and dilute the solution with four times its weight of soft pure water. Characters written with it, do not appear till the paper is warmed; when the traces of the pen are visible, under a fine sea green color. This color disappears as the paper cools, and is renewed on warming again; and thus alternately vanishes and re-appears, for an indeterminate number of times. As the solution of regulus of cobalt, or zaffre in spirit of nitre, acquires a reddish color, by application of heat, so a variety of color may be given. Thus landscapes may be sketched with common ink, to give a prospect of winter; while the solution of cobalt in aqua regia, on the application of heat, gives the verdure of spring; and the nitrous solution may represent fruit, flowers, &c.

CALX of MANGANESE.

CALX of manganese mixed with glass, gives it a red or purplish color. In a larger portion it produces a deep purple color. The manganese is used
for

for giving a black colored glaze, which is composed of twenty-one parts of white lead, five parts of powdered flints, and three parts of manganese. This is used for common earthen ware.

On the CALCES *and* PRECIPITATES *of*
MERCURY.

MERCURY dissolved in the nitrous acid may be precipitated;

First, Of a white color, by adding a solution of sal ammoniac to the nitrous solution, and carefully precipitating with a solution of fixed alkali.

Secondly, Of a brownish red color, by precipitating the nitrous solution with fixed alkali, or lime-water.

Thirdly, Of an orange color, with pure mineral alkali.

Fourthly, Of a rose color, with urine.

Fifthly, Of a vermillion red, with Beguin's spirit. Which is sulphur dissolved in caustic volatile alkali, by the application of a digesting heat.

Sixthly, Of a blue color, with Meyer's extract of Berlin blue; which is the coloring matter of Prussian blue extracted with volatile alkali. And

Seventhly,

Seventhly, Of a black color, with a solution of liver of sulphur.

How far these precipitates of mercury, may be used as pigments depends upon future trials.

A TABLE of the WEIGHT and COLOR of METALLIC PRECIPITATES.

100 Grains.	Precipitated by	Wght.	Color.
Gold in Aqua Regia.	Aerated min. al.	106	Yellowish
	Caustic ditto	110	Darker, retains more Acid
	Prussian ditto	—	Yellowish or bluish
Silver in Nitrous Acid.	Aerated, &c.	129	White
	Caustic	112	White
	Prussian	145	Brick color, or if dilute flesh color
	Marine Acid	133	White clouds
Copper Nitrous Acid.	Aerated	194	Bluish green
	Caustic	158	Greyish brown
	Prussian	530	Dark red
Iron Vitriolic, or Marine Acid.	Aerated	225	Greenish brown, soon after yellowish
	Caustic	170	Darker brown
	Prussian	590	Blue
Tin Aqua Regia, or Marine Acid.	Aerated	131	White
	Caustic	130	White
	Prussian	250	Dark green, grows blue
Lead Nitrous Acid.	Aerated	132	White
	Caustic	126	White
	Prussian	—	Greenish yellow, grows white
	Vitriolic Acid	143	White grains
Mercury Nitrous Acid.	Aerated	110	Brick color
	Caustic	104	Yellower
	Prussian	—	White and yellow, with spots of green
	Vitriolic Acid	130	White
Zinc Nitrous Acid.	Aerated	193	} Dull white
	Caustic	161	
	Prussian	495	Reddish yellow, grows whitish yellow

100 Grains.	Precipitated by	Weight.	Color.
Regulus of Antimony.	Aerated	140	} Dull white
	Caustic	138	
	Prussian	—	Blue, easily re-dissolved by excess, then green
Bismuth Nitrous Acid.	Aerated	130	} White
	Caustic	125	
	Prussian	180	Reddish yellow
	Water	113	White
Nickel Nitrous Acid.	Aerated	135	} Whitish green
	Caustic	128	
	Prussian	250	Dirty reddish yellow, or red and greenish yellow
Cobalt Nitrous Acid.	Aerated	160	} Greenish pale red
	Caustic	140	
	Prussian	142	Blue, greyer than that of iron
Arsenic Marine Acid, or Aqua Regia.	Aerated	—	} White imperfect
	Caustic	—	
	Prussian	180	Green and yellow mixed
Manganese Nitrous Acid.	Aerated	180	} Brownish red when dephlogisticated, or white
	Caustic	168	
	Prussian	150	if phlogisticated Dirty bluish grey, grows brownish grey.

These precipitates are supposed to be well washed in distilled Water; and dried in a Heat of 212° of Fahrenheit, to which they are exposed for ten Minutes.

PART IV.

A

SHORT ACCOUNT

OF THE

PRINCIPAL DISEASES

OF

METALLIC ARTISTS;

WITH SOME PLAIN DIRECTIONS

CONCERNING THEIR

PREVENTION and CURE.



*Of the DISEASES of METALLIC ARTISTS,
and the MEANS of PREVENTION and
RELIEF.*

IN the application of metals to the different arts, the persons employed, are often injured to a great degree, by some of the particles entering their bodies; either in consequence of being swallowed along with the spittle, drawn in along with the breath, or absorbed by the pores of the skin. For the benefit of such persons, therefore, we shall here give a short account of the principal disorders, to which they are severally exposed; together with some plain and general directions, respecting their prevention and cure. In doing this, we shall follow the order in which the metals have been already considered in the preceding parts of the book; passing by those in the working of which no material injury happens.

G O L D.

AS the mischief which is done to the constitution by gilding, proceeds entirely from the mercury employed

ployed in the process, we shall reserve what we have to say thereon until we come to treat of the effects of that peculiar metal.

C O P P E R.

THE makers of verdigrise and verditer; painters who grind and mix this last preparation with oils; and braziers, but in a slighter degree, are liable to take in some cupreous particles, which disorder the constitution somewhat in the same manner as lead. They acquire a fallow countenance, their hair becomes greenish, with which color their spittle, which has besides a brackish taste, and excrements are likewise tinged. They waste away and become prematurely old. They are affected with tremblings of the limbs, and pains and twitchings in the stomach and bowels; which last, however, are not always constipated, as is the case from lead, but are sometimes on the contrary, very loose.

Such persons should take care to throw out their spittle during their work, and never neglect to wash their hands and face, and even change at least a part of their clothes, such as their coats and waistcoats, when they leave off. It would be a great convenience in point of cleanliness, and a great advantage in point of health, for all such persons to put on something like a wagner's

goner's frock while at work, laying it aside again when they have done. This would be found in the end, to be a great saving in clothes; and what is still more desirable, a great saving in physic. These remarks will equally apply to those, who work at any of the other injurious metals.

For the above mentioned complaints, after they have once come on, mild and softening methods will generally answer best; such as the use of broths, gruel, or milk and water. If there is much uneasiness at the stomach, some camomile tea should be taken, so as to occasion vomiting. If the pains and twitchings are violent, a draught of peppermint water, with fifteen or twenty drops of laudanum will be proper; and if the bowels are bound, some senna tea should be taken, or what is still better, an electuary, composed of an ounce of lenitive electuary, and half an ounce of flowers of brimstone, mixed up with some syrup of marsh-mallows. A tea spoonful, or the size of a walnut, to be taken till it procures a stool or two. But on the other hand, if, as sometimes happens, there should be a purging, the peppermint draught, with laudanum above mentioned, should be repeated every three or four hours, until it is checked. After the pain has been removed, and the bowels have been sufficiently cleansed, by keeping them moderately open, a tea spoonful of the Peruvian bark in powder may be taken twice
a day,

a day, in a glass of cold water, for about a week, care being taken that it does not bind up the body, for if it has that effect it will not be proper. People that dislike the electuary, may take some magnesia and rhubarb in its place.

IRON.

DURING the forging and hammering of iron, the scales which fly off, frequently get into the workmen's eyes, and if not quickly dislodged, occasion great inflammation and pain. The common methods of removing them, are washing the eye with cold water, or picking them out with a needle, in performing of which, some of the workmen are very dextrous. But these methods sometimes fail, in which case, recourse must be had to the magnet; which will frequently succeed, and is then found the easiest and most expeditious extractor. If any inflammation should remain, the eye may be washed afterwards with a cooling eye water, made by dissolving fifteen grains of white vitriol, in half a pint of cold water. The disorders of grinders of iron, being produced by the particles of the stones, and not of the metal, cannot be properly noticed here. but polishers and steel grinders, from the great use of emery, and oil, are very subject to indispositions of the stomach and bowels. The general symptoms are

are oppression of the stomach, costiveness, and frequently pain in the bowels; but they are easily removed by a gentle vomit, giving the next morning some opening physic, and taking plentifully of broths, &c. When the pain continues after the purgative, it may be removed by giving oily purging mixtures, with the addition of a little laudanum.

T I N.

THE inconveniencies which happen to pewterers, enamellers, and all those that are any wise employed in the melting of tin, either by itself or along with other metals, proceed chiefly from the particles of arsenic which it contains, and will be more properly noticed therefore amongst the effects of that semi-metal.

L E A D.

LEAD miners, plumbers, letter-founders, refiners, the makers of cerusse, painters, &c. are subject to a peculiar kind of colic, called the dry belly ach, which often ends in a palsy of the upper, and
O some-

sometimes of the lower limbs of the body. This disorder, which is occasioned by the particles of lead, is marked by the following symptoms.

The countenance becomes fallow, the appetite fails, with an uneasiness and sickness at the stomach, and great costiveness. The pain, which is greatest about the naval and loins, comes on by degrees, increasing at length to such a violent pitch, as to cause frequent vomitings, and in many cases, a drawing in of the belly at the navel; where it feels hard, and cannot bear to be pressed.

Under these circumstances, the first thing to be done, is to take some camomile-tea, so as to provoke vomiting, and thereby clear the stomach; after which twenty drops of laudanum should be swallowed in a glass of water, and repeated every two or three hours until the pain is abated, or sleep is brought on. If on waking the pain returns, the laudanum draughts must be repeated again in the same manner. By pursuing this mode of treatment for three or four days, during which time the patient must be supported by broths and other spoon meats, the pain and hardness of the belly are generally removed, so as to allow of the employment of purging medicines, of which the mildest sort usually answer best; such as a drachm of cream of tartar, or in its place, two drachms of Epsom or Glauber's salts, dissolved in a little warm water, or senna-tea, and taken every

two

two hours until the bowels are opened. Some recommend for this purpose, the oil of ricinus or palma christi. Half an ounce, or six drachms of it may be swallowed for a dose in a glass of peppermint water, there being no occasion to mix it up, as is commonly directed, with the yolk of an egg. As much as an ounce of it at a time has been given to some patients; but in such quantities the stomach is seldom able to retain it. Should the pains still return, the laudanum draughts should be again employed, and if these are not effectual, opiate glysters should be likewise administered.

To obviate the costiveness, which sometimes lasts a long time, and which, if not carefully removed, brings on a relapse, some gentle opening physic must be used daily; such as cream of tartar, senna-tea, or the electuary with flowers of brimstone as mentioned already in treating of the effects of copper.

In order to defend themselves from the bad effects of lead, all those that are in any manner exposed to its daily influence, should eat some fat broth, or bread spread thick with butter or lard, before they enter upon their work. It is with the same intention that some have recommended a glass of salad oil, with a little brandy, to be taken fasting. In other respects the precautions concerning cleanliness, as noticed under the article copper, are equally proper here.

MERCURY.

THE fumes of this singular metal, to which gilders, looking glass makers, the preparers of vermillion, sublimate, &c. are particularly exposed, disorder the body in a frightful manner. The chief complaint which they induce is a trembling and palsy of the limbs; but these are accompanied with many other distressing symptoms.

The countenance looks heavy, pale, and yellow. The gums are corroded, and easily bleed; the teeth, which are turned black, become loose, and sometimes fall out; the inside of the mouth is covered with ulcers, and there is a continual flow of spittle. The breath is very foetid, and the respiration is obstructed. The neck, arms, and legs, are affected with tremblings, and at length become quite paralytic. Along with all this, there is commonly some degree of stammering, and now and then a total loss of speech; together with deafness, and a general dulness and stupor of the senses.

Such persons, unless they change their employment, seldom live to an old age.

The cure of these formidable complaints, consists first of all in expelling the mercurial particles out of the body, which is chiefly done by means of sweating; and afterwards in employing proper medicines, to remove the spasms and weakness of the limbs.

After

After giving an emetic, the first intention is answered by going into the warm bath, and then, after being laid in bed between the blankets, taking a dose of Dover's powder; the operation of which must be assisted by drinking every now and then a little warm gruel, tea, or weak wine whey.

Care must be taken to keep in bed as long as any sweat comes out; and after getting up, not to go into the cold air. This sweating plan must be persisted in for some time, repeating it at first every night, then every other night, and towards the end, thrice, twice, or only once a week. During this, some of the decoction of the woods may be taken in the day time. After the sweatings, if the body should be bound, it must be opened by some fennatea, or the electuary with flowers of brimstone, already described. The food should be light, but nourishing; consisting chiefly of milk, broths, and puddings.

After the mercurial particles have been thus expelled, which is known by the disappearance of the most distressing symptoms, the warm bath and sweating powder may be laid aside; and bracing and strengthening medicines may be now employed. Amongst these, the best for this purpose, are pills composed of equal parts, of the gum pills, and extract of gentian, viz: a drachm of each, beat up together, and divided into twenty-four pills; of which

three are to be taken night and morning. Electricity is likewise of use. If much weakness should still remain, notwithstanding these medicines, half a drachm of powdered bark may be swallowed down in a glass of cold water twice a day; taking care at the same time that it does not occasion costiveness. At this time, the cold bath and steel medicines will be likewise proper.

Gilders should be particularly cautious to turn their heads aside as much as can be, during their work; for by properly attending to this, they would escape most of the fumes. They should moreover always contrive, as much as possible, by opening the windows, or door of the place where they are at work, to have a current of air from behind them towards the chimney. Where this could be managed, especially if a brisk fire were at the same time kept up, the mercurial fumes, instead of being diffused in the atmosphere around them, would be immediately carried away in a body up the chimney.

With regard to the diet of such people, it should be nourishing, but quite temperate. Whenever they feel themselves much disordered, they should take a vomit; and they should always be careful to keep their bodies moderately open.

It is no unusual practice with people employed in working quicksilver mines, to put on gloves and masks furnished with glass eye-holes. Gilders would
do

do well to imitate them in both these respects. They can have no objection to follow the first; and a little reflexion will serve to convince them of the propriety of overcoming every prejudice against the last of these precautions.

ARSENIC.

MANY of the ores of silver, and some of those of tin, antimony, &c. as has been already shown in the first part of our book, contain a portion of arsenic, to the vapors of which the workmen are exposed during the pounding, roasting, and smelting of those metals. The same thing happens likewise in the making of pewter, enamels, and all compound metals, in which arsenic is used as an ingredient.

In which soever of these ways, the arsenical fumes come to be applied to the human body, they never fail to disorder it to a violent and even dangerous degree.

When they are not applied in such considerable quantity as to prove an immediate poison, they operate so as to undermine the constitution in a slow, but effectual manner.

They seem to act chiefly on the nervous system, inducing a constant feverish state, with loss of appe-

tite, sickness, and occasional vomiting, and daily wasting away of the flesh. The stomach and bowels are often tormented with twitching pains; and there is a general trembling of the limbs, with giddiness and head-ach. The breathing is moreover very much disturbed, and a distressing asthma is often brought on. Unless they are checked in due time, these symptoms go on increasing, till the hectic fever becomes confirmed, and then the patient dies consumptive.

For the mitigation or removal of these complaints, it will be proper to take a gentle puke of camomile tea or ipecacuanha; and afterwards to keep the body open by mild purges, such as senna-tea, or the electuary with brimstone. Where there is much costiveness, or any great fulness or swelling of the belly, a glyster should be thrown up. A gentle sweat should likewise be kept up, by the frequent use of small quantities of warm decoction of barley, milk and water, or linseed-tea; and at night, especially if there be much pain or twitching of the stomach or bowels, fifteen or twenty drops of laudanum may be taken in a draught of any of the liquids just now mentioned. The warm bath may be also employed with advantage. It will be of great service too to take once or twice a day for some length of time, small doses, such as fifteen or twenty grains of flowers of brimstone, mixed up with a little milk. A French physician of considerable repute, has recommended

mended in these cases, the liver of sulphur. It may be made up into pills, and given in the dose of four or five grains, with a draught of warm water after it.

The diet should be the same as that prescribed for gilders, viz. it should consist chiefly of milk. For restoring the strength, and completing the cure, bitters and steel medicines should be employed, viz. pills composed of a drachm of extract of bark, half a drachm of extract of gentian, and fifteen grains of salt of steel, beat up together, into twenty pills. Three to be taken night and morning.

All that has been said under the article mercury, respecting cleanliness, and the other means of prevention, applies with equal propriety here.

Besides the disorders already mentioned, there are some others occasioned by the vapors of the mineral acids, and the fumes of charcoal; but as these do not depend upon the particles of the metals themselves, and as they are moreover common to many other sorts of artists, it cannot be expected they should be treated of here.

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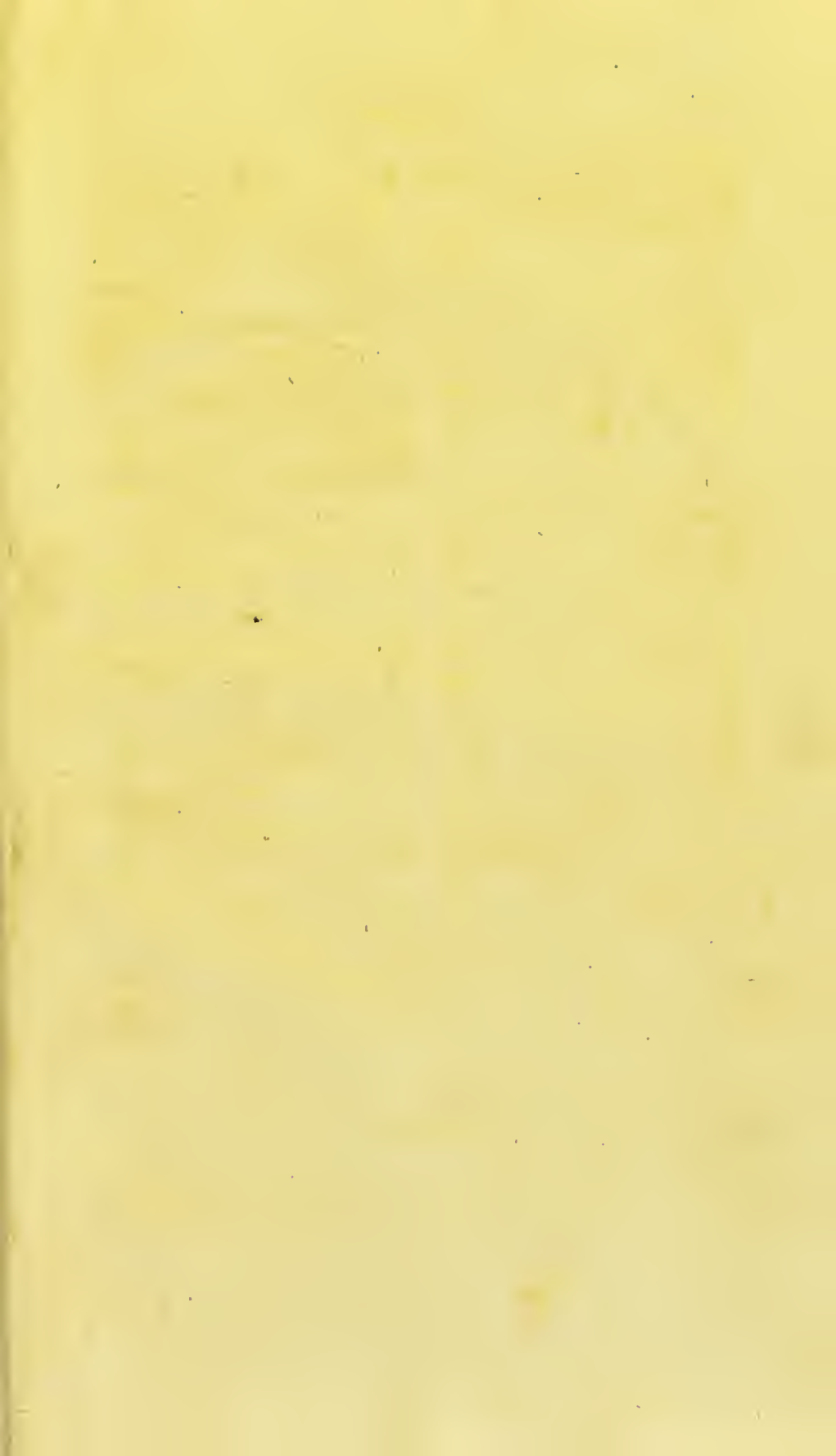
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